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Using client-server approach to design a generic Local Area Network (LAN) for Naval Academy of Republic of China (ROCNA)

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THESIS

USING CLIENT-SERVER APPROACH TO DESIGN A GENERIC LOCAL AREA NETWORK (LAN) FOR NAVAL ACADEMY OF REPUBLIC OF CHINA (ROCNA)

by

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March, 1996

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This thesis demonstrates the application of design theory as it relates to the generic LAN for the Naval Academy of the ROC (ROCNA). The first part of the study covers a theory dealing with system analysis and design, network technology and data communication. This is used for a foundation for the development of a end-user survey and feasibility study for the ROCNA LAN. Chapter III of this study is a background of the ROCNA and an analysis of the Naval Academy's network requirements. In Chapter IV a generic LAN is developed to meet the ROCNAs requirements and different alternative designs are investigated. A cost-benefit analysis is performed to select between the design alternatives.

The design selected uses a point to point connection dual ring backbone and a 10BaseT star topology for subnetworks. Finally, recommendations and conclusions are presented in Chapter V for more emphasis on information technology education in the ROC Armed Forces and specifically at the ROCNA.

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This thesis demonstrates the application of design theory as it relates to the generic LAN for the Naval Academy of the ROC (ROCNA). The first part of the study covers the theory dealing with system analysis and design, network technology and data communication. This is used for a foundation for the development of a end-user survey and feasibility study for the ROCNA LAN. Chapter III of this study is a background of the ROCNA and an analysis of the Naval Academy's network requirements. In Chapter IV a generic LAN is developed to meet the ROCNAs requirements and different alternative designs are investigated. A cost-benefit analysis is performed to select between the design alternatives.

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I. INTRODUCTION

This is an era of information; the person who can obtain information quickly enough can seize an opportunity. In order to distribute new information as quickly as possible, efficient and effective networks are the only solution. Presently, there is a great deal of interest and activity in the design and use of distributed Local Area Networks (LANs). These networks are being researched, developed, produced, and marketed by individuals and organizations from government, industry, and academia. These activities are motivated by:

- Rapidly changing technologies of devices and systems.
- Increased performance requirements.
- Increasing complexity and sophistication of interconnections and control.
- The constant demand for improved reliability and availability.
- The increasing reliance of organizations on the use of computer facilities in all aspects of business. (Fortier, 1990, p. 1)

Fast networks have higher capacity and can allow multimedia data to pass over them. The development of Information Technology (IT) is changing so rapidly that to maintain and keep up with the "State of the Art" in this technology is very difficult and is a serious concern of even the most technological advanced nations.

The Clinton/Gore technology announcement of February 1993 explicitly recognizes that information technology can:

> ... dramatically improve the way the Federal Government serves the people, thereby making the government more cost-effective, efficient, and user-friendly. The Administration must continue to make provision of government services a central aspect of the National Information Infrastructure (NII) design.

A. BACKGROUND

Since early 1990, the NII was generally recognized by most advanced IT countries, like the United States, Canada, some European countries, Japan, and Singapore and others. The NII provides access to government services and information. Presently the plan to develop the NII in the Republic of China (ROC) has been carried out by Industry and Technician Research Center (ITRC) using the Fiber Optic Networks (FONs), in a step by step process intended to encompass the entire island of Taiwan. As of the start of 1995, some parts of Taiwan have been connected and the FONs tested. The Local Area Networks (LANs) are the elementary units of the NII and are required to working properly if the potential of the FONs is to be realized. Therefore, establishment of a proper LAN for Republic of China Naval Academy (ROCNA) not only meets the requirement of users at school but also fulfills the policy of the government.

The author did some interviews in the ROC during the summer break 1995 in different schools, including ROCNA. From the interviews, one conclusion is that schools seldom do a feasibility study or significant research before building their own LANs. Sometimes, a LAN is not designed around an organization's needs, but is acquired because it is an available technology and may serve some poorly defined need of its advocate. In response to this situation, my study will address a methodology, like a Standard Operation Procedure (SOP), to deal with designing any kind of LAN.

B. PURPOSE

The purpose of this thesis is the application of academic theory to conduct a thorough research on a generic network design focusing on system analysis and design approach, requirement definition, cost/benefit analysis, and network design, and to produce an appropriate design for the implementation of a network for the ROCNA. This methodology can be applied for network prototyping in many different kinds of organizations. The only difference that must be accounted for are the number of end users and the local environment.

C. SCOPE

This study is directed at a generic LAN design; there are several topics that will be covered:

- Briefly discuss the synthesis of theory that will be used later in the LAN design.
- What is the environment for a Local Area Network (LAN) of ROCNA?
  - Military environment.
  - Information systems environment.
  - Survey of ROCNA user needs.
- What are the requirements for a Local Area Network (LAN) for ROCNA?
  - What are the mission and objectives?
  - What are the requirements?
    - The users' requirements.
    - The LANs requirements.
- What is the Local Area Network design?
  - Identify the geographic scope.
  - Design network configuration.
  - Evaluate software/hardware considerations.
  - Calculate network costs.
  - Consideration of implementation of the network.

D. METHODOLOGY

The methodology used in this study consisted of the development of a survey, based upon academic theory, to determine information and communication needs as

related to the LAN. The survey also captured personal attitudes and opinions concerning the automation of office work and the perceived usefulness of a LAN. Statistical analysis of the data obtained from the survey is performed. The inferences from this analysis provides an insight into the users' requirements that can contribute in the design and implementation of a LAN.

E. ORGANIZATION

Chapter II provides the theoretical framework and methodological background on the facets of system analysis and design and LANs technology. Chapter III begins with a study of the existing system. Also, an overview of the military and information system environment is presented. Information requirements are identified and discussed in terms of current capability, current needs, and the future requirements. Chapter IV presents the LAN design of ROCNA, network alternatives, calculated network costs, and discusses implement considerations. Chapter V presents conclusions.

II. SYNTHESIS OF THEORY

A. INTRODUCTION

This chapter will present an overview of Local Area Networks (LANs) and the current technology used for their implementation. This chapter will provide a background and terminology to be used in the remainder of the thesis for the design of a LAN for the Chinese Naval Academy.

Until the early 1970s, computers were immovable objects and the people who wished to use a computer and its resources, brought their work to the computer. In the mid-70s Minicomputers were developed and organizations found it possible to distribute these resources and make them more available to end users. The current period is characterized by the desktop computer where, in fact, the user has a more powerful tool than any of the minicomputers that were networked in the mid-70s. In the mid-70s, it was found that the hierarchical communication structure used to communicate information between computers and the user were breaking down and not maintainable. The concept of distributed communications was developed to solve this problem. (Martin, 1990, p. 571-573)

B. SYSTEM ANALYSIS AND DESIGN

The concepts of system analysis and design have naturally evolved, along with computer technology. In the 1960s and early 70s, the methods of system analysis were less structured because the computer systems of the times were isolated and presented a hierarchical communication structure represented by the end user at best connected to a mainframe by a terminal and at worst submitting computing tasks through a window to the computer's operator. This description is equivalent to a personal computer with a large off-line storage in a very small memory. As the technology evolved, the systems have become much more sophisticated and their communication structure is distributed along with the resources available to any one end user. This is equivalent to the 1960s

concept of connecting literally thousands of computers together that have very large memories and a reasonable off-line storage, installed in the end user office. As can be seen by the above description, the problems of systems analysis and design are much more difficult and as a consequence, the tools of systems analysis have evolved to enable the designer to produce the analysis and design for a working system. (Whitten, 1994)

1. System Design Method

The system design method is illustrated in Figure 1. The method consists of 13 phases marked as letters A - M. Each phase is further subdivided into subphases marked with a letter followed by a number for that subphase. The first section A - C is an analysis of the problem and the development of a requirements document to be used in the next phase. The next phase D - H is the planning and design of the project and the evaluation of alternate solutions to the problem. In the final section, I - M, is the production of the system and evaluation to see that the system meets the requirements developed in the first section A - C.

This method will be used in the analysis both the structure and design process for the Naval Academy LAN. The purpose of this procedure, is to produce the best possible system which will meet the end users' requirements for the LAN. By following the procedure, the designer of the system can ensure that every relevant user requirement is included in the design. (Whitten, 1994)

2. System Development Life Cycle (SDLC)

The system development life cycle is a continuous process that is not only used in the initial development of the LAN, but throughout the systems operation to provide solutions to the problems of the end users. Any sophisticated system must continually evolve to keep pace with evolving user requirements and new technologies. The SDLC has five phases shown in Figure 2.

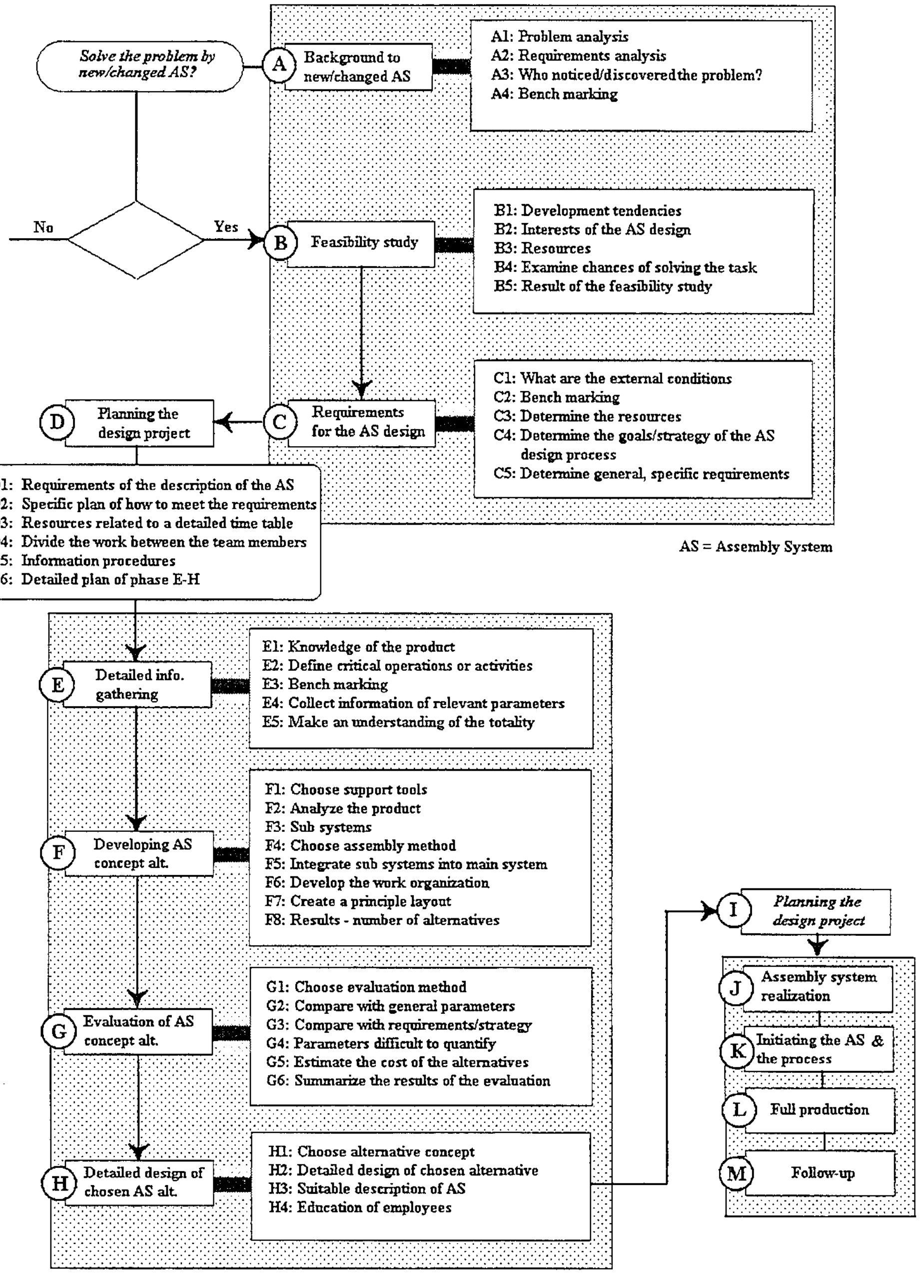

Figure 1. System Design Method (SDM)
From [Johansson, 1994, p. 54]

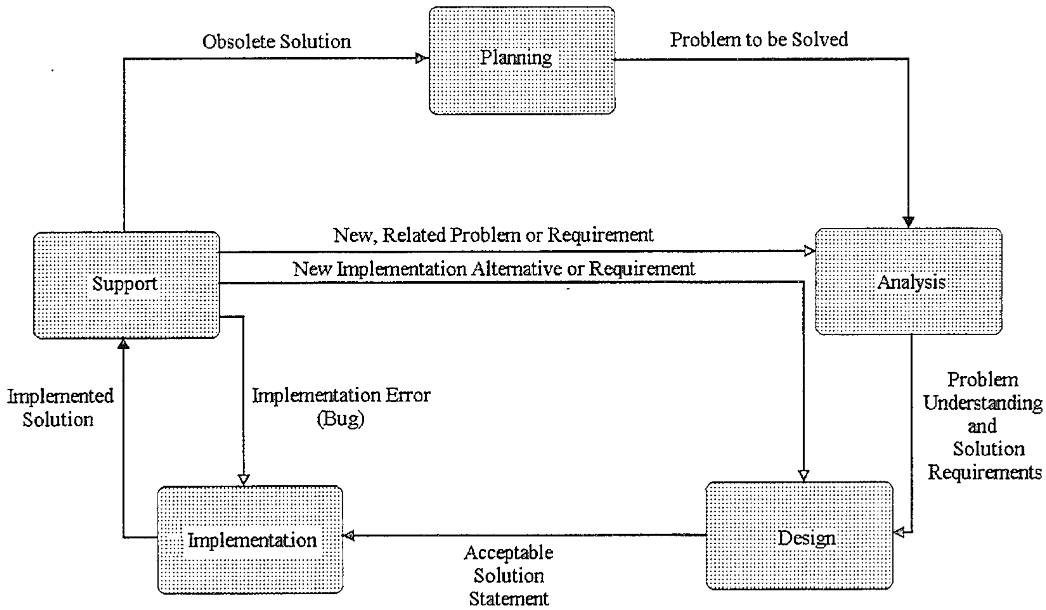

Figure 2. A Systems Development Life Cycle.
From [Whitten, 1994, p. 12]

a. Planning

Planning is the process of identifying the problems in the system and their possible solutions with the goal of selecting solutions that will provide the greatest benefit to the end users of the LAN.

b. Analysis

Analysis is the study of the problem and its definition. It is also a determination of the priority of its solution. The analysis is performed from the viewpoint of the end user with a goal meeting the end users' requirements and is not performed with a view of possible solutions for the LANs system.

c. Design

The design phase is the evaluation of alternative solutions and the production of a detailed specification for the selected solution to the end users' problem. In this phase, the focus shifts from the end users' point of view to a viewpoint which considers possible computer solutions to the end users' problem. (Whitten, 1994)

d. Implementation

Implementation is the installation of the solution which was selected in the design phase.

e. Support

Support is the ongoing maintenance and documentation of the implemented solution. This period lasts for the length of time that the solution is in use in the system. Support provides feedback to the analysis, design and implementation phases to enable both the improvement of the implementation for the current problem solution and provide experience for the solution to other end user problems. This phase also will identify end user and system problems that may need to be addressed.

In Figure 3 is a diagram of a SDLC. Steps 1 and 2 are equivalent to the planning stage. Step 3 would be analysis. Step 4, 5, and 6 would be the design phase. Step 7 and 8 would be the implementation phase. At various points in the SDLC diagram, there are feasibility checkpoints. These points are used to ensure that a problem and its solution are possible to implement with the current technology or are solvable with a computer solution. Additionally, these points represent where the cost benefits analysis of a solution should be performed. (Whitten, 1994)

3. Network Modeling

The LAN represents a resource to the end user of the system. This resource must provide for the requirements of the end user. As part of this process for the creation of a new LAN or connections to an existing LAN, the LAN must be evaluated for its performance and to anticipate future end user requirements.

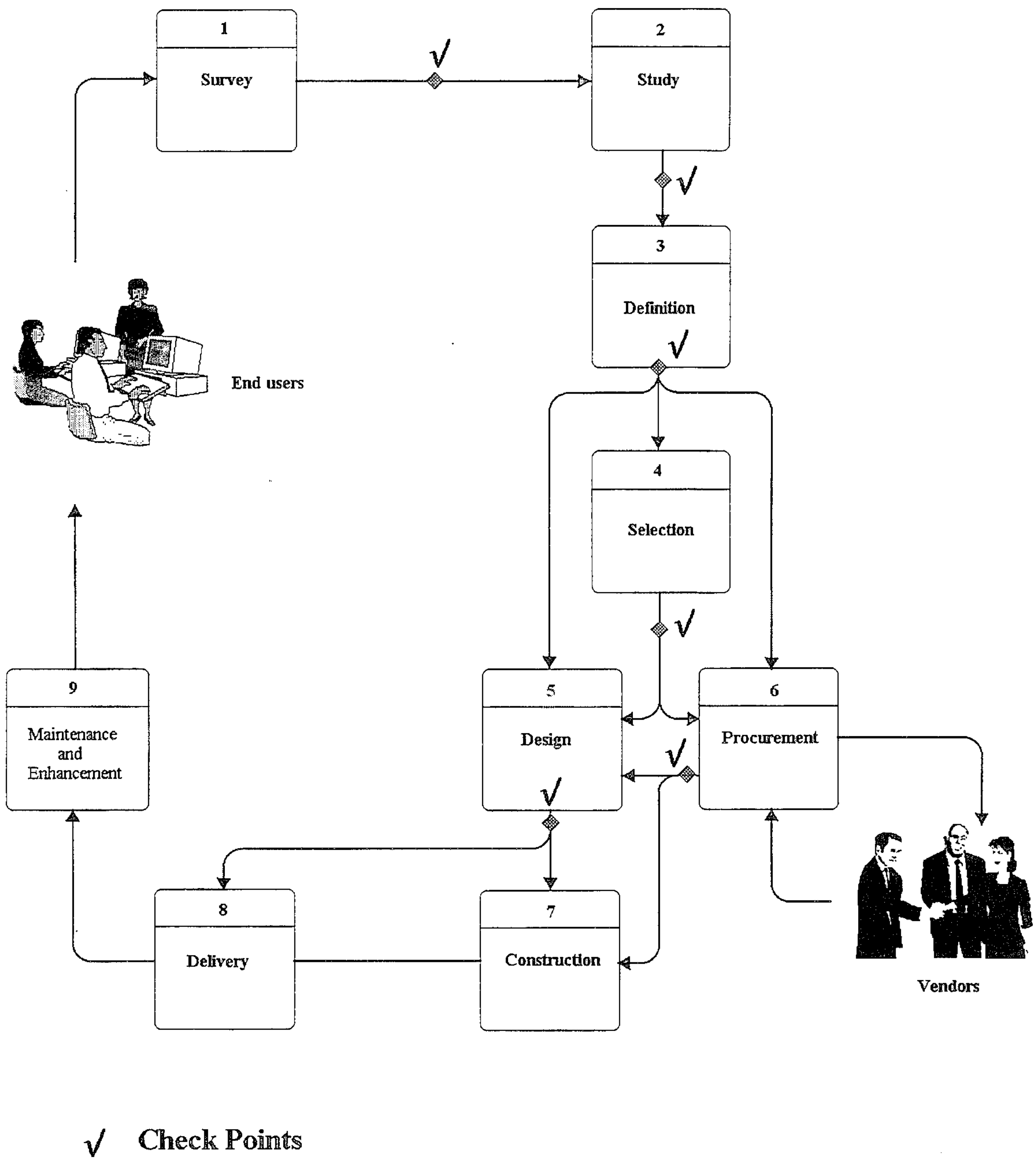

Figure 3. Feasibility Checkpoints In The Systems Development Life Cycle.
From [Whitten, 1994, p. 813]

Modeling should be done as early as possible in the design process. The modeling should also be documented to provide for future expansion or modification of the LAN. A good model of the system, including both the end users' software requirements and the hardware limitations of the LAN, will enable the designer to select the most cost effective alternatives for the design. Additionally, the designer can provide a blueprint for the expansion of the system in the future. (Whitten, 1994)

C. NETWORKS TECHNOLOGY

Networks technology includes both the hardware used in the physical LAN and software used by the end users and the various servers in the LANs system. At this time, the leading edges of practical LAN technology are in hardware, fiber-optics and in the software, client/server systems. If the LAN at the Chinese Naval Academy were being built from the ground up these would be the technologies that would be used. However, the Chinese Naval Academy has LANs using older technologies which must be integrated into the new system. In this section, we will briefly cover, not only the new technologies used in the design of a LAN, but technologies currently used at the Chinese Naval Academy.

D. SOFTWARE TECHNOLOGY

Computer technology is unique, in that the design of a system is the design of a tool whose final use is not known to the designer. Invariably end users find unique solutions to problem after they are presented with the final design of the system. The element that makes this possible is the software that makes up the system.

1. Open Systems Interconnections (OSI)

The software technology that has made networks possible is the Open Systems Interconnections (OSI) for developing network software. The OSI model is shown in Figure 4. This model was intended for the development of standard protocols for communicating between computers. This model is an architectural model for the

development of the protocols and only sets a framework for the design of the network systems. The system is a layered system with seven layers. (Stallings, 1994)

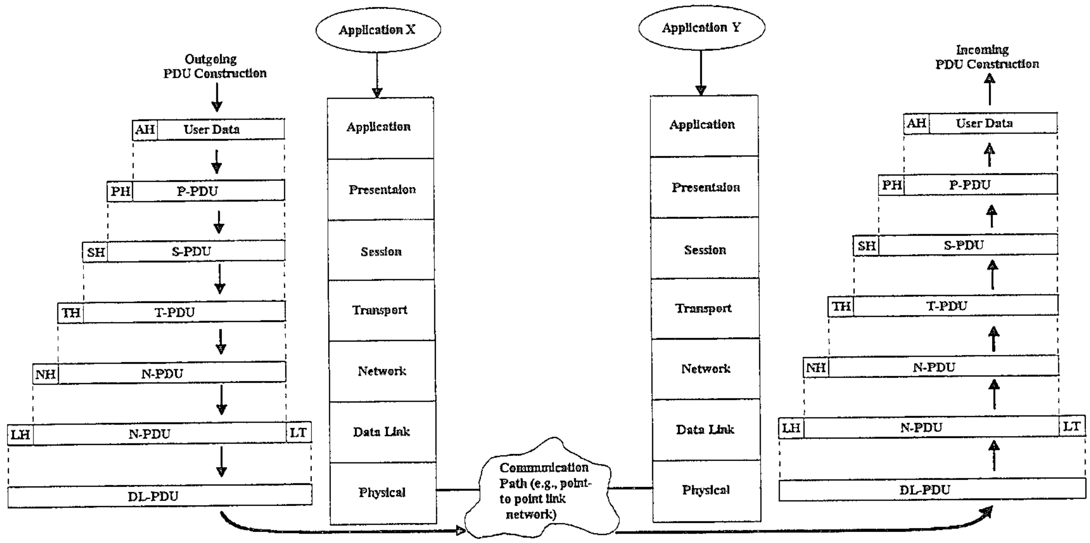

Figure 4. The OSI Environment.
After [Stallings, 1994, p. 440]

a. Physical Layer

The lowest layer is the physical connection between the computers and includes the hardware and the manufacturer's software for its operation. This layer cannot guarantee the transmission and reception of information and higher layers must implement error detection and recovery procedures. (Stevens, 1990, pp. 171-196)

b. Data Link Layer

The next layer up from the physical layer, is the data link layer. This layer is responsible for transferring a frame of information from one system to another and ensuring that there has been no transmission error between the systems. Because all the points in a network system transfer information at this level, at the same rate, this layer is also responsible for flow control of the network. This is normally accomplished by a

program either embedded in the network interface card or executed directly in the computer. (Stevens, 1990)

c. Network Layer

The network layer handles the routing of information to be transmitted on the network. The network layer is always represented by a software program running in the computer. In some network environments, this is the last layer implemented from the point of view of the operating system of the computer. (Stevens, 1990)

d. Transport Layer

The transport layer's purpose is to ensure an error free connection is made between the transmitter and receiver on the network. This layer and the layer's above are required only on computers which are in communication with another computer on a network. The layers below this point are required on all computers connected to the network. Although this layer ensures a error-free connection, it cannot ensure that a connection can be made between the two computers. (Stevens, 1990)

e. Session Layer

The session layer's purpose is to set up and close down specific instance of communication between the two programs in each computer. This layer is rarely implemented in the software as a separate layer and instead, is part of the two layers above. (Stevens, 1990)

f. Presentation Layer

The presentation layer is responsible for formatting the information to be passed between the two programs in communication. This layer has, like the session layer, is specifically created for the end users' application. This is also the layer that would implement security measures for the information passing from program to program. (Stevens, 1990)

g. *Application Layer*

The application layer is the end users' application. In most cases, the application layer, the presentation layer and the session layer are, in fact, the application that the end user is running.

h. *Summary*

The OSI model is an architecture for the development of software. By developing software with this model, in layers, it is possible for the developer to ensure that the product will work on a system using standard protocols. This model and the design of the operating systems used in the computer, ensures a segmentation that allows a network to be a device for the general use of software and not a specific connection dedicated to a specific use. Before the development of this architecture, connections between computers required very expensive custom support for software. This was common in the 1960 and 70s, where each connection between computers programs was unique and known only by a few programming personnel.

In Table 1, is a summation of the OSI architecture and the function of each of the seven layers. Figure 4 is the OSI environment with two applications x and y in communication over the network. As can be seen in Figure 4, this process is normally implemented by adding data to the head or tail of a frame transmitted over the network. When data is received these headers or trailers are stripped from the frame as it moves from the physical layer to the application layer. The stripped headers are used at each level to perform the functions of that level in the architecture. In the real world, it would be unusual to find an implementation that included all seven layers of the OSI model.

2. Protocols

Protocols are a set of procedures that specify how the two computers will communicate. This includes the format, timing, sequencing of data and error checking. Network systems may use more than one protocol by multiplexing at the physical and data link level of the OSI model.

Category	Definition
Physical	Concerned with transmission of unstructured bit stream over physical medium; deals with the mechanical, electrical, functional, and procedural characteristics to access the physical medium.
Data link	Provides for the reliable transfer of information across the physical link; sends blocks of data (frames) with the necessary synchronization, error control, and flow control.
Network	Provides upper layers with independence from the data transmission and switching technologies used to connect systems; responsible for establishing, maintaining, and terminating connections.
Transport	Provides reliable, transparent transfer of data between end points; provides end-to-end error recovery and flow control.
Session	Provides the control structure for communication between applications; establishes, manages, and terminates connections (sessions) between cooperating applications.
Presentation	Provides independence to the application processed from differences in data representation (syntax)
Application	Provides access to the OSI environment for users and also provides distributed information services.

Table 1. The OSI Layers.
From [Stallings, 1994, p. 438]

a. TCP/IP

The most common protocol is TCP/IP (Transmission Control Protocol, and Internet Protocol) or the protocol used on the Internet. This protocol is actually a series of protocols developed by the Department of Defense. A more accurate name for the protocol is the DARPA (Department of Defense Advanced Research Projects Agency) Internet protocol. TCP/IP is a suite of several networking protocols, developed for use on the Internet. The only real competition for the TCP/IP suite is provided by protocols that have been or are being developed for emerging OSI Model. The relationship of these protocols and the OSI model are shown in Figure 5. The main protocols in the suite include the following: (Stallings, 1994)

- SMTP (Simple Mail Transfer Protocol) Provides a simple electronic-mail (e-mail) servers. It uses the TCP protocol to send and receive messages.

- FTP (File Transfer Protocol) enables users to transfer files from one end to another. It also uses the services of the TCP protocol at the transport layer to move the files.

- TELNET provides terminal-emulation capabilities and allows users to log in to a remote network from their computers.

- SNMP (Simple Network Management Protocol) is used to control network-management services and to transfer management-related data.

- TCP (Transmission Control Protocol) provides connection- and stream-oriented, transport-layer services. It uses the IP to deliver its packets.

- UDP (User Datagram Protocol) provides connectionless transport-layer service. It also uses the IP to deliver its packets.

- IP (Internet Protocol) provides routing and connectionless delivery services at the network layer.

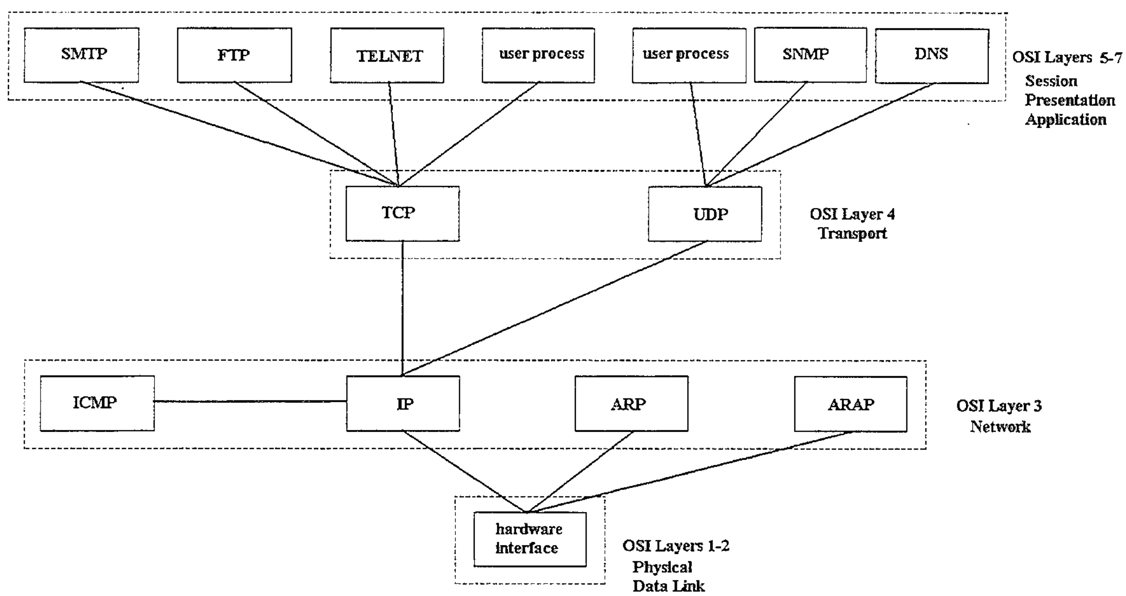

Figure 5. TCP/IP Protocols.

- ARP (Address Resolution Protocol) Used to map to a 48 bit Ethernet address from a 32 bit IP address. (Rose, 1991)
- RARP (Reverse Address Resolution Protocol) Used to map to a 32 bit IP Address from a 48 Bit Ethernet address.(Rose, 1991)

b. IPX/SPX Protocol

This protocol was created in 1983 by Novell Inc.. It is very popular network operating system used in LAN because it's flexible, efficient, and fase. This protocol is based on Xerox Networking System (XNS). This protocol is very similar to the TCP/IP protocol. IPX is Internetwork Packet Exchange and SPX is Sequential Packet Exchange. IPX provides a connection similar to the IP portion of the TCP/IP protocol. In that the connection is not guaranteed. SPX supports IPX in providing a connection-oriented reliable delivery between two applications running on the network.

c. Summary

These two protocols are the most common software protocols in use. Each uses an operating system feature called sockets. This feature was developed initially on UNIX computers and essentially is an operating system implementation of the OSI architecture.

3. Client-Server Model

The client-server model provides for further optimization of the computer resources of an organization. By dividing the end users' interface to the computer system from the services that the network/computer resources provide a users' problem can be divided into specialized programs and services distributed across the network. This distribution of resources means that the maintenance of the data and programs is a much simpler process. For example, a database needs only to be maintained in one computer system, but can supply services to any number of programs and support a number of users. The database presents an interface to a series of programs tailored to a users' needs. The users' software is created specifically for the user and needs only to interface with the common database and present an interface specifically tailored to the end users'

needs. There are two efficiencies gained in this model. The first, it is only necessary to maintain and update one database. The second, it is much simpler to maintain a suite of small programs that perform a limited function than a suite of very large programs that perform every function in a transaction. Figure 6 illustrates the client/server model.

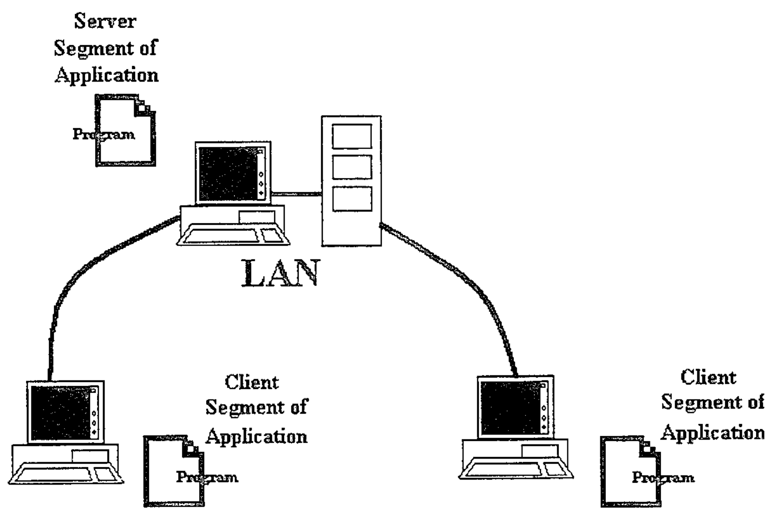

Figure 6. Client-Server Model

4. Operating System Trends

With few exceptions, the vast majority of workstations and desktop computers use Microsoft operating systems. Economically, the hardware that these systems run on, and the software used for the end users' support is much less expensive than the remaining percentage of computer operating systems. Currently, Microsoft is not shipping any operating system that does not include network support. Windows 95 which cannot

operate as a server on a network still can connect to a network in any number of software protocols including TCP/IP and IPX/SPX (NWLink an expanded application interface, including IPX/SPX). In the network operation system (NOS) aspect, it is not easy to determine a best NOS for your network. Basically it depends on the needs of the users and on how much money you are willing to spend. The current NOSs using in the market are: NetWare series like Server for OS/2, 3.12, 4.1, Windows NT Server 3.5 and Workstation 3.5, IBM LAN Server, Banyan VINES, Peer-to-Peer Networking. There are many peer-to-peer systems available from different companies, such as Novell Personal NetWare, Microsoft Windows for Workgroups (WFW) or Windows 95, AppleTalk, etc.,

5. Summary

The above information may seem overly detailed for the architectural design of a network, but when selecting software to solve the problems of the end user, it is necessary to know what protocols the software will support. Additionally, to provide for the future needs of the end user, it is necessary to select the protocol that will be used throughout the system and ensure that the protocol can be supported in the future by software developers.

E. HARDWARE TECHNOLOGY

The hardware LAN is the physical components of the LAN. Not only the cable connecting the computers on the network, but other devices which are needed to ensure an error free transmission path from transmitter to receiver. Figure 7 shows some of these components.

1. Repeaters

A repeater is an electronic device used to extend the physical length of the network. Repeaters operate at the physical level of the OSI model.

2. Bridges

Bridges are usually an electronic device to copy the transmission from one network to another. Bridges differ from repeaters, in that they operate at the physical and data link level of the OSI model.

3. Routers

Routers are usually a computer program and hardware connections which route transmitted information from one network to another. These systems usually include software to make decisions relating to the most efficient path for a transmission. Routers operate at the network layer of the OSI model.

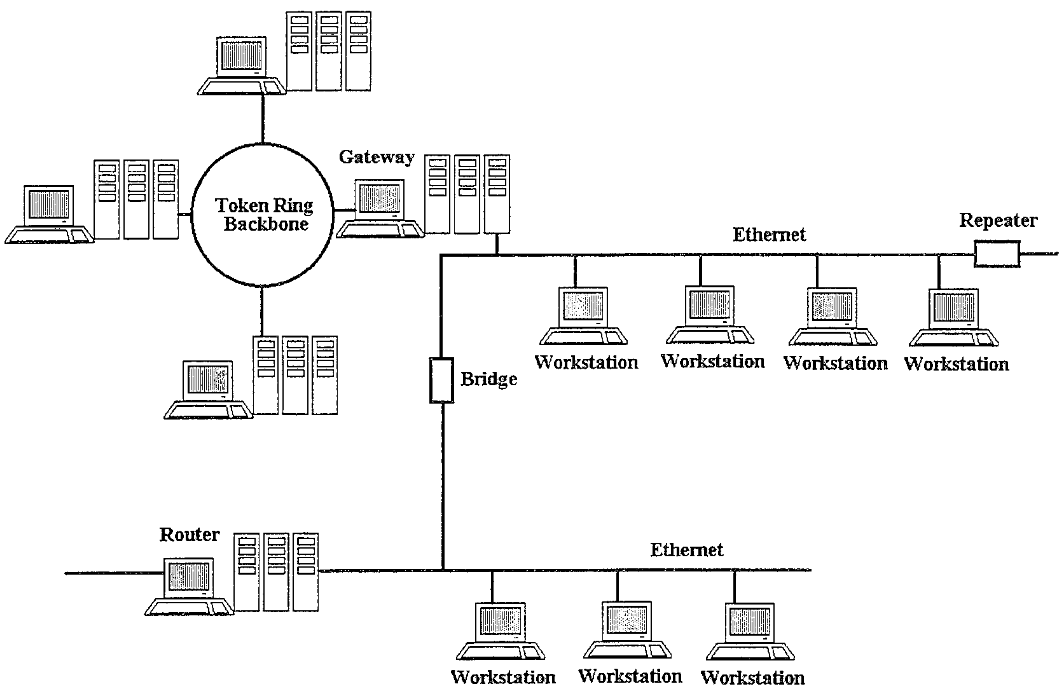

Figure 7. Network Components.

4. Gateways

A gateway is a computer connected to more than one network which routes information from one network to another. Gateways is a genetic term which includes routers. Usually gateways are implemented at the network level of the OSI model. When

this term is used, it sometimes refers to conversions of a network level transmission to another format for a different communication protocol.

5. Network Topology

A LAN topology can be described by physcial or logical layout. There are two kind of methods to identify the logical topology, managed and contention. Logical ring uses the managed method, like IBM token ring LAN; Logical bus uses the contention method, like Ethernet LAN. Physical topology uses wiring method to determine its LAN layout. It can identify form the shape of wiring, like star, bus, ring, and tree etc., (see Figure 8 through 12) The advantages and disadvantages of these topologies are shown in Table 2. For the trend purpose, we can consider the following type of LAN using at the LAN of Chinese Naval Academy.

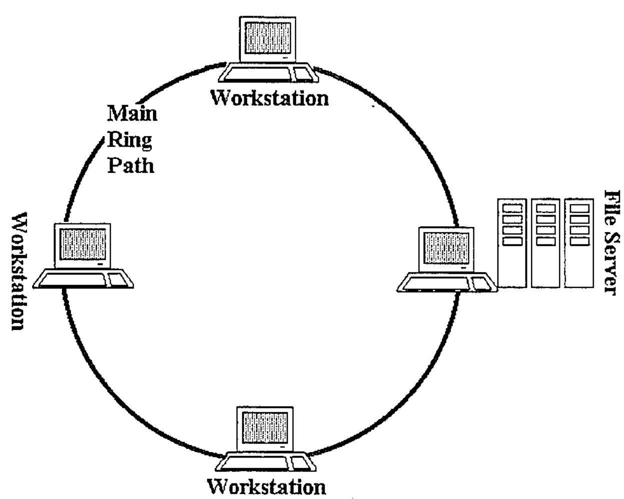

Figure 8. Ring Topology.
After [Feibel, 1995, p.997]

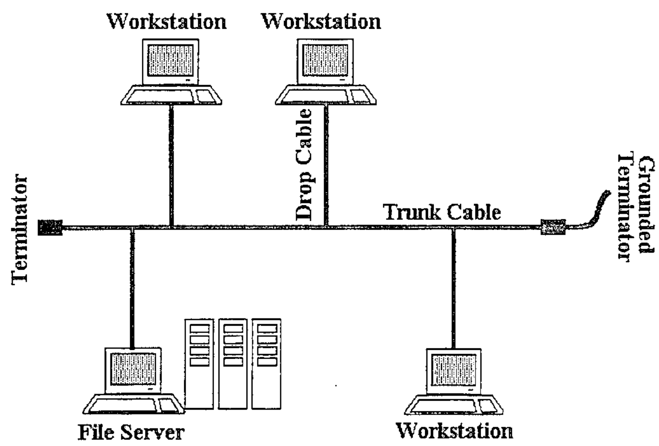

Figure 9. Bus Topology.
After [Feibel, 1995, p.995]

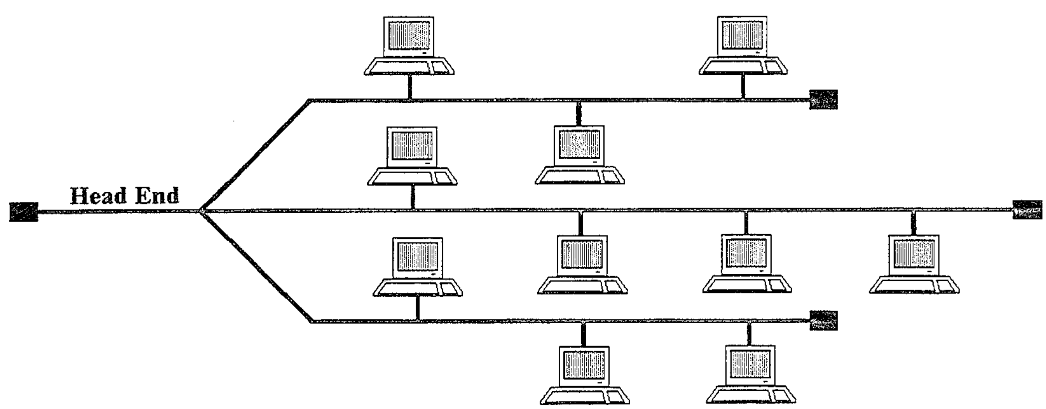

Figure 10. Tree Topology.
After [Feibel, 1995, p. 1002]

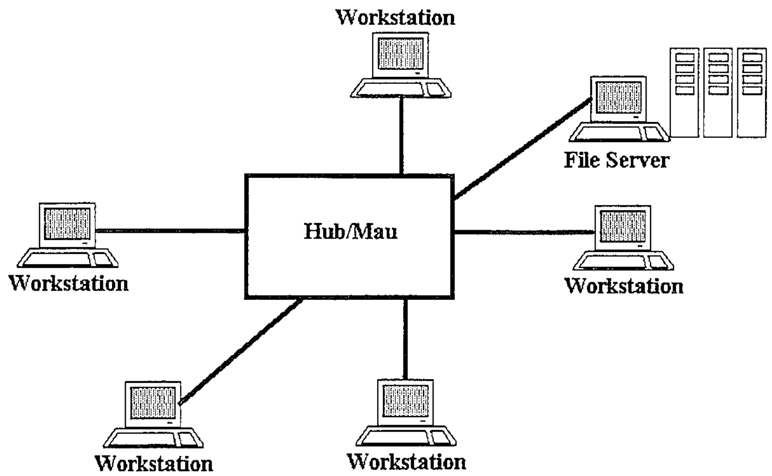

Figure 11. Star Topology.
After [Feibel, 1995, p. 999]

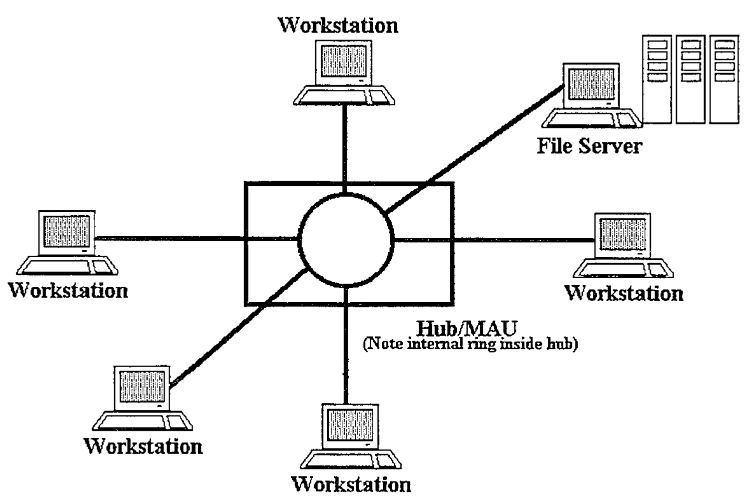

Figure 12. Star-wired Topology.
After[Feibel, 1995, p.1001]

	ADVANTAGE	DISADVANTAGE
BUS	• A bus uses relatively little cable compared to other topologies. • Easy to add or remove nodes from a bus; Easy to extend a bus topology. • Architectures based on this topology are simple and flexible.	• Diagnosis/troubleshooting (fault-isolation) can be difficult. • The bus trunk can be a bottleneck when network traffic gets heavy.
RING	• The cable requirements are fairly minimal, and no wiring center or closet is needed.	• If any node goes down, the entire ring goes down. • Adding or removing nodes disrupts the network.
STAR	• Troubleshooting and fault isolation are easy. • It is easy to add or remove nodes, and to modify the cable layout.	• If the hub fails, the entire network fails. (sometimes a backup central machine is included, to make it possible to deal with such a failure.) • A star topology requires a lot of cable.
TREE	• The network is easy to extend by just adding another branch, and that fault isolation is relatively easy.	• If the root goes down, the entire network goes down. • If any hub goes down, all branches off that hub go down. • Access becomes a problem if the entire conglomerate becomes too big.
HYBRID (Star-Wire Ring)	• Troubleshooting, or fault isolation, is relatively easy. • The modular design makes it easy to expand network, and makes layouts extremely flexible. • Individual hubs can be connected to form larger rings. • Wiring to the hub is flexible.	• Because of the extreme flexibility for the arrangement, configuration and cabling may be complicated.

Table 2. Overview of LAN's Topologies.

After [Feiber, 1995]

a. IBM Token Ring Network

IBM token ring network architecture arranges in a physcial star topology to connect all the node to the central ring; Each nodes under the limitations can add or remove form the ring without affect its connectivity. It uses a token-passing strategy to

control access to the network. Figure 13 is a summary of the token ring process. The characteristics of IBM token ring network show as following:

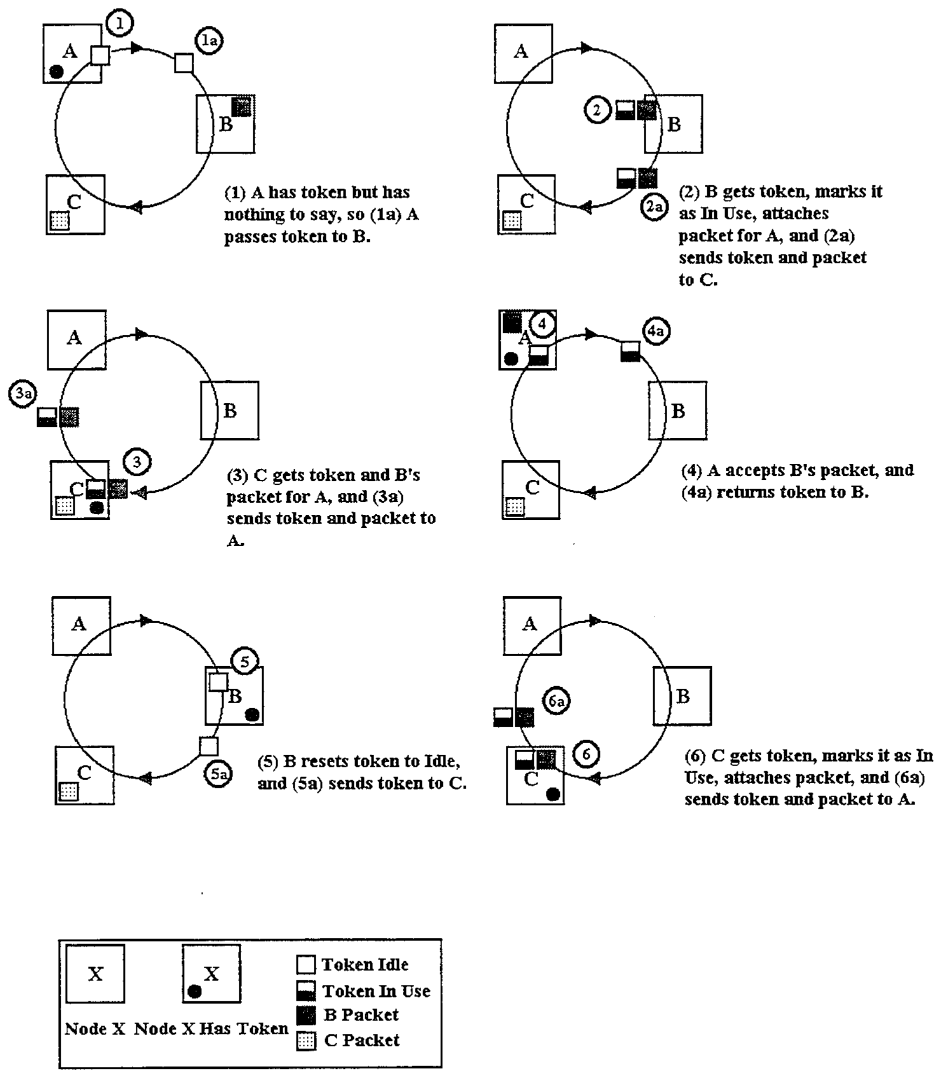

Figure 13. Summary Of The Token-Passing Process.
From [Feibel, 1995, p. 967]

- Transmission speed up to 16 Mbps
- Using the twisted pair or fiber-optic cable, but not coaxial cable.
- Each nodes takes turn to get a token; Collisions are not possible.
- High overhead at low load; Good performance at moderate and high load.
- Add or remove a node form the ring does not affect the connectivity. (Maximum of 260 nodes on a single network)

b. Ethernet

An Ethernet connection is a single connection terminated at both ends connected to all the computers on the network. This connection may be done with fiber-optics, coaxial cable, twisted pair, or shielded twisted pair. This is one of the most common method of networking computers. Figure 14 is a description of Carrier Sense Multiple Access/Collision Detection (CSMA/CD). Ethernet requires a system that can detect whether the network is in use by another computer. Electronically this would be relatively simple except when two computers attempt to use a network at the same moment and time. Although, at first glance, this would seem to be unlikely. If identical programs are running in identical computers, this can happen. On Ethernet systems when the computer finds the network busy, it waits a random period of time before attempting to use the system. These configurations have advantages that are related to ease of maintenance or installation of the system.

c. Fiber Distributed Data Interface (FDDI)

FDDI is a LAN and WAN standard based on the use of fiber optic cable wired in a physical ring or star. it is commonly used for campus-wide network. The FDDI scheme is very efficient, especially in large rings. The system can operate up to 100 megabytes per second, which make it suitable for applications such as multimedia and video. Figure 15 shows the topology of this system. This is the latest technology in use

and naturally it is much more expensive than the established technology. The characteristics of FDDI network show as following:

- Can provide and maintain a guaranteed bandwidth.
- Supports up to 1000 nodes on the network.
- Supports transmission speeds up to 100 Mbps.
- Supports nodes up to 2 km apart with multimode cable; up to 40 km single-mode cable

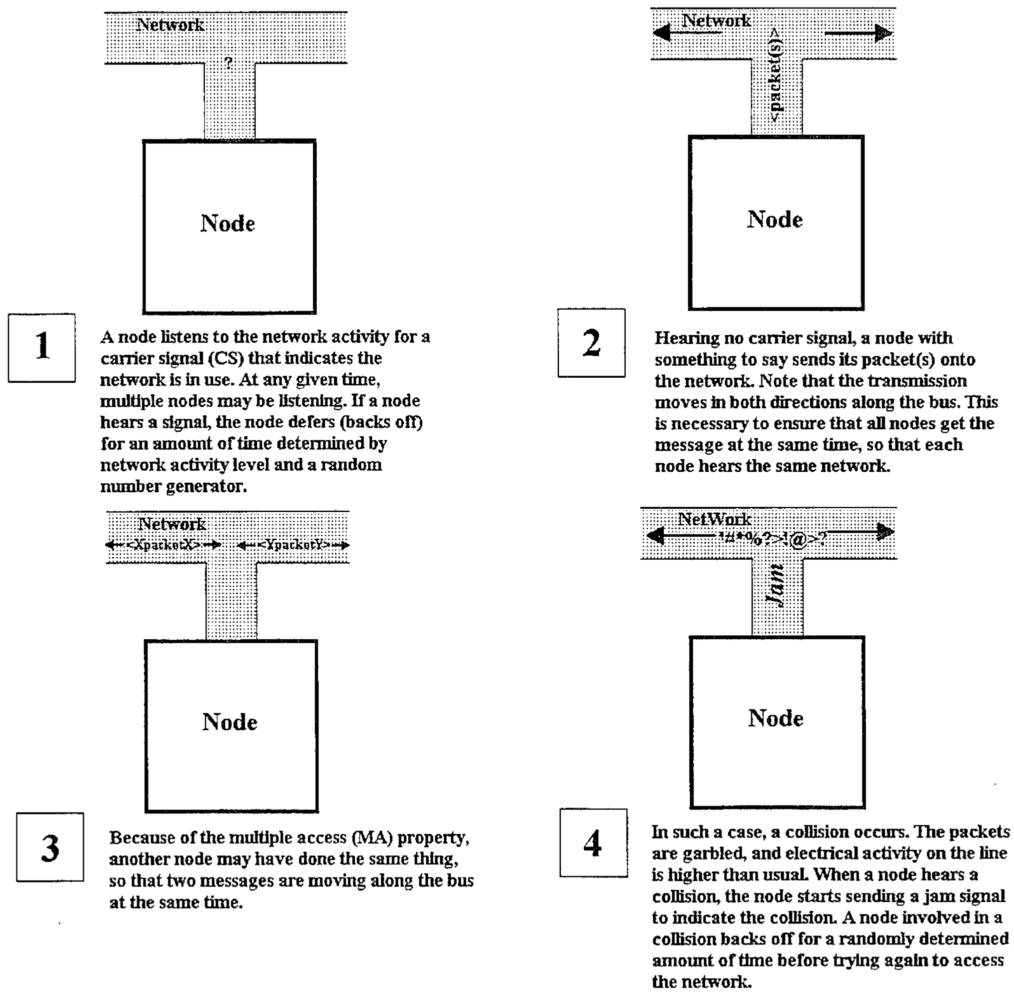

Figure 14. Summary Of The CSMA/CD Process.
From [Feibel, 1995, p. 230]

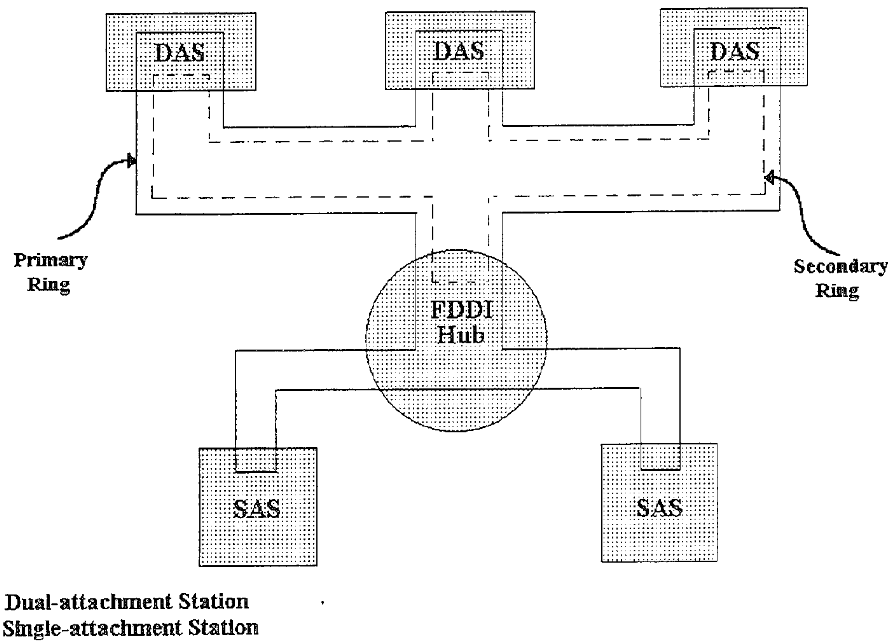

Figure 15. Optical Cable Topology for a FDDI LAN.
From [Fitzgerald, 1994, p. 530]

F. DATA COMMUNICATION MEDIA

Table 3 and Table 4 are a summary of the most common transmission media for local networks. In recent years the cost of fiber-optics cable and the electronics to support the network has become competitive with the older technologies of twisted pair and coaxial cables. In a new installation it is not any more difficult to install optical fiber than the other technologies. Table 5 through Table 8 lists the advantages and disadvantages and the properties and uses of the various transmission media. Since the existing networks are quite small and would be considered essentially a network which runs from one room to another, it would be to the advantage of the Chinese Naval Academy to install optical fiber

cable systems for their new network. This would delay obsolescence for a number of years.

Transmission Medium	Data Rate (Mbps)	Range (km)	Number of Repeaters
Uushielded Twisted Pair	4	0.1	72
Shielded Twisted pair	16	0.3	250
Baseband Coaxial cable	16	1.0	250
Optical fiber	100	2.0	240

Table 3. Transmission Media for Local Networks: Ring

From [Stallings, 1994, p. 345]

Transmission Medium	Data Rate (Mbps)	Range (km)	Number of Taps
Twisted Pair	1-10	< 2	10's
Baseband Coaxial cable	10; 50 with limitations	< 3	100's
Broadband Coaxial cable	500; 20 per channel	< 30	1000's
Optical fiber	45	<150	500's

Table 4. Transmission Media for Local Networks: Bus/Tree

From [Stallings, 1994, p. 346]

Properties	• Stable and predictable electrical properties • At least one shield around conductor wire • Subject to electromagnetic interference • Variable impedance levels (52, 75, 93 ohms, and many other impedance values in between) • Thin (cheapernet) and thick varieties (10 Base 2, 5) • Broadband and baseband varieties • Thin coax uses BNC/TNC connectors; thick coax uses N-series connectors • Twinaxial runs two cables within a single jacket • Triaxial and quadrax have extra shielding for special users
Uses	• Ethernet networks • ARCnet networks • Cable TV lines • Video cable • IBM mainframe and midrange-based networks (twinaxial) • Telephone switching offices

Table 5. Context And Properties Of Coaxial Cable.

From [Feiber, 1995]

	Shielded Twisted-Pair (STP)	Unshield Twisted-Pair (UTP)
Properties	• Includes shield around twisted pairs 150 ohm impedance • Information in differential signal between wires in a pair • Subject to electromagnetic interference Generally uses RJ-xx connectors	• No shield around twisted pairs • 100 ohm impedance • Information in differential signal between wires in a pair • Subject to electromagnetic interference • Generally uses RJ-xx connectors • Performance grades specified in EIA/TIA-568 1-5
Uses	• IBM Token Ring networks • ARCnet networks • Rarely in Ethernet networks	• 10 Base-T Ethernet networks • ARCnet networks • Certain sections of IBM Token Ring networks • Telephone Lines (voice-grade)

Table 6. Context And Properties Of Twisted Pair Cable.

After [Feibel, 1995, p. 161]

Properties	• Medium for light signals • Comes in single-mode (thin fiber core; single light path) and multi-mode (thick fiber core; multiple light paths) versions • Smaller size and lighter weight • Very high bandwidth • Immune to electromagnetic interference, eavesdropping • Lower attenuation • Greater repeater spacing
Uses	• FDDI networks • Long-haul lines • To connect network portions or networks • To connect mainframes to peripherals • To connect high-speed, high-performance workstations

Table 7. Context And Properties Of Fiber Optic Cable.

After[Feibel, 1995, p. 141]

	Advantage	Disadvantage
Twisted Pair	• It is easy to connect devices to twisted-pair cable. • If an already installed cable system, such as telephone cable, has extra, unused wires, you may be able to use a pair of wires from that system. • STP does a good job of blocking interference. • UTP is quite inexpensive. • UTP is very easy to install. • UTP may already be installed (but make sure it all works properly and that it meets the performance specifications your network requires	•STP is bulky and difficult to work with. •STP is more susceptible to noise and interference than coaxial or fiber-optic cable. • UTP signals cannot go as far as they can with other cable types before they need cleaning and boosting. • A skin effect can increase attenuation. This occurs when transmitting data at a fast rate over twisted-pair wire.
Coax	• Broadband coaxial can be used to transmit voice, data, and even video. • The cable is relatively easy to install. Coaxial cable is reasonably priced compared with other cable types.	• It is easily damaged and sometimes difficult to work with, especially in the case of thick coaxial. • Coaxial is more difficult to work with than twisted-pair cable. • This type of cable cannot be used with token-ring network architectures. • Thick coaxial can be expensive to install, especially if it needs to be pulled through existing cable conduits. • Connectors can be expensive. Baseband coaxial cannot carry integrated voice, data, and video signals.
Fiber Optic	• Light signals are impervious to interference from EMI or electrical crosstalk. Light signals do not interfere with other signals. • Fiber-optic lines are much harder to tap, so they are more secure for private lines. • Light has a much higher bandwidth, or maximum data-transfer rate, than electrical connections. • The signal has a much lower loss rate, so it can be transmitted much further than it could be with coaxial or twisted-pair cable before boosting is necessary. • Optical fiber is much safer, because there is no electricity and so no danger of electrical shock or other electrical accidents. • Fiber-optic cable is generally much thinner and lighter than electrical cable, and so it can be installed more unobtrusively. • Cable making and installation are much easier than they were in the early days.	• Fiber-optic cable is currently more expensive than other types of cable. • Other components, particularly, NICs, are very expensive. • Certain components, particularly couplers, are subject to optical crosstalk. • Fiber connectors are not designed to be used as often as you would like. • Many more parts can break in a fiber-optic connection than in an electrical one. • Generally, they are designed for fewer than a thousand matings. After that, the connection may become loose, unstable, or misaligned. The resulting signal loss may be unacceptably high.

Table 8. A Comparison Of The Transmission Media. (Feibel, 1995)

G. SUMMARY

In this chapter, we have covered the current practical technologies will be used for LANs at ROCNA and shown some of the advantages and disadvantages of these systems. In real terms, the hardware to be used in the LANs is a much less important decision than decisions about the number of workstations per LAN, software to be made available to the end users, ensuring that any equipment and software purchase will function with the commercially existing standards that the LAN is designed to use and the design method used to create the LAN and its documentation.

III. RESEARCH APPROACH FOR THE ROCNA LAN

The most difficult element of the design of a local area network is discovering the current and future requirements of the network users. (Held and Sarch, 1983, p. 366) Establishing the requirements for a local area network differs from establishing the requirements for a particular application development. In an application development, the developer determines the data inputs to a process, and the process that will produce the required outputs. In the development of an organization's information system, it is necessary to study the information flow of the organization and understand how the flow of information contributes to the organization's objectives.

The Republic of China Naval Academy (ROCNA) is a military academy environment. The first section of this chapter will examine a military academy environment. The second section will outline the information systems environment of the ROCNA and present the results of a user survey at the ROCNA. The final section of this chapter will define the networks requirements based on both the survey of the network users and the environment at the ROCNA.

A. THE MILITARY ACADEMY ENVIRONMENT

The ROCNA was established in Shanghai in mainland China in 1946. Since 1949 when the Republic of China government was moved to the Island of Taiwan as a result of a military takeover by the Chinese Communists, the academy has been on a 110 acres site in the First Military District at Tso-Ying, Kao-Hsiung. The academy is divided roughly into four districts: academic district, the administrative district, the military quarters district and a physical exercise area.

1. Environmental Overview

The ROCNA is a unique organization that occupies the highest levels of educational organizations in the ROC. The ROCNA is required to follow the lead of the Department of Defense (DoD), the Department of the Navy, and other relevant government organizations. Midshipmen may graduate with an academic diploma or a

Bachelor of Science Degree. Graduates will be commissioned as ensigns in the ROC Navy when they acquire the necessary credits during the two and a half years or four year course of study at the academy. Majors are offered in the subject areas of Oceanography, Applied Science, Applied Mathematics, Electronic Engineering, Mechanical Engineering and Information Management. There are approximately 600 students in the academy at any given time including midshipmen and a Petty Officer Advanced Class. The faculty is comprised of an integrated group of military and civilian of approximately 80 percent and a 20 percent support group of civilian employees.

There are no postgraduate degrees offered at the academy. Projects and papers are limited to the personal research work of the professors and work assigned by the instructors and professors to the students. This lessens the demand for high performance computing resources that would be required at a more technically oriented university. The midshipmen lead very structured academic lives that results in a varying but predictable demand on computer resources.

2. Mission and Functions

The formal mission of the ROCNA is:

> To combine philosophy, science, and the military sciences in a military educational environment with the principle of developing the special military needs in general education. Conducted in an environment of military routine and higher education. To enable midshipmen to become a modern naval officer with a knowledge of technology, clear reasoning and logic, creativity, and leadership, as a solid foundation for his or her development in the future. (ROCNA, p. 13)

The objective of education at the Naval Academy is to educate young men and women as professional naval officers and develop their skills in staff and leadership. In order to achieve these objectives, their educational environment should include the normal facilities of any higher educational school but also the modern technical facilities of computers, communications, and the proposed LAN. Additionally, the LAN can also provide services for the realization of office automation and improve the efficiency of the faculty and staff.

3. Organization

The organization of the ROCNA is a traditional hierarchy. This hierarchy is shown in Figure 16 and Figure 17. The hierarchy is divided into two groups: Figure 17 is the education group and Figure 16 is the administrative group. The administrative group is responsible for the operation of the school and administrative duties such as: planning, personnel, logistics and budget operations. The Educational Department is responsible for faculty, students, curriculum and research.

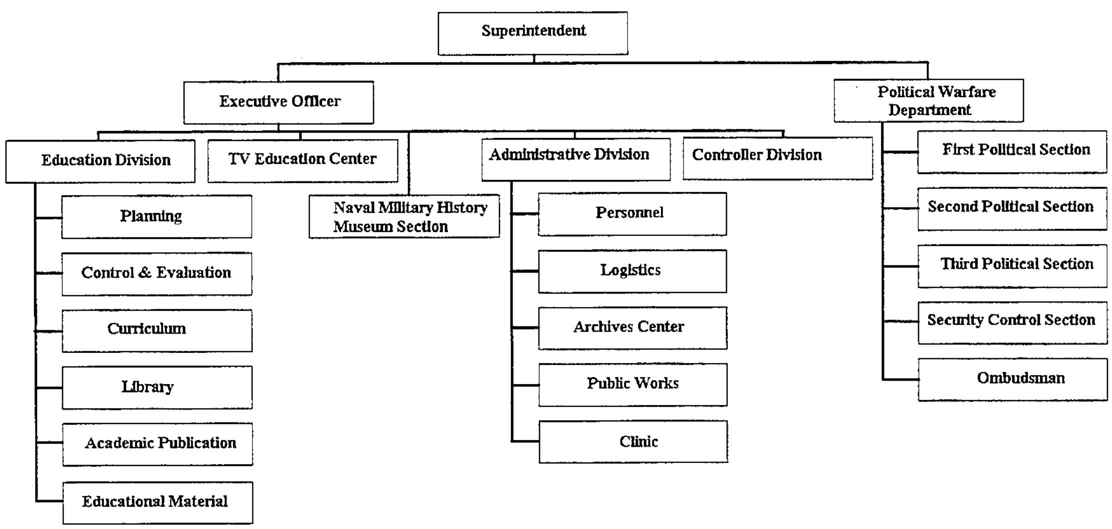

Figure 16. Administration Organization.

B. THE INFORMATION SYSTEM ENVIRONMENT

The rapid improvements in computer technology has brought on obsolescence to the ROCNA information systems in only the last five years. The encouraging aspect of this obsolescence is that it is timed perfectly with the establishment of the Taiwan Academy Network (TANet) and the budget authority to upgrade the ROCNAs LAN and library automation in 1997. This will provide for the ROCNA a connection to the ROCs Universities and modernize the ROCNAs equipment.

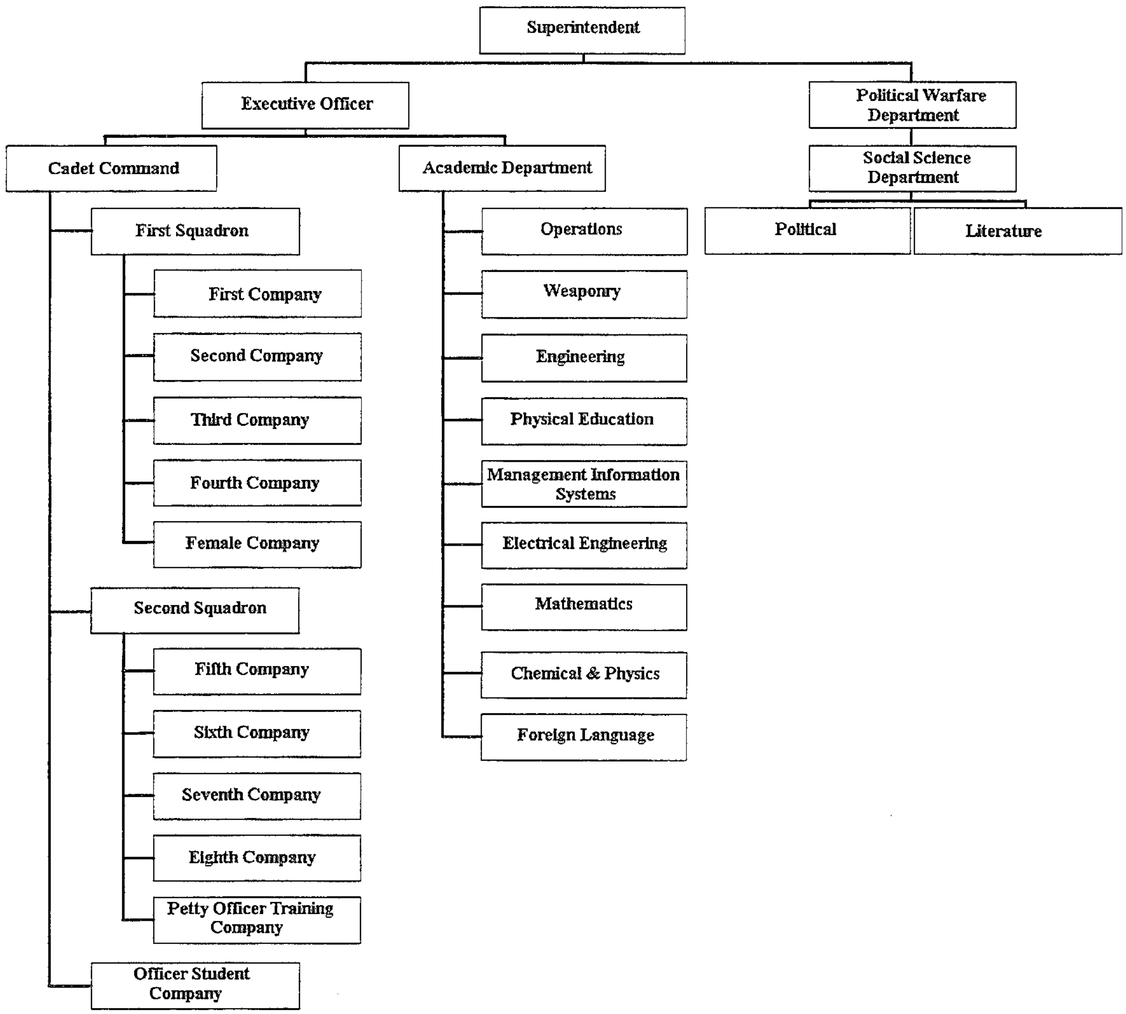

Figure 17. Education Organization.

1. Current Data Operation Capabilities

Every office or division of the ROCNA operates as an independent entity with its own computers and resources. Many of the staff prepare paperwork by hand but any

paperwork that must leave the school is prepared on computers or typewriters through the Archives Center of the Administration Department.

In order to familiarize midshipmen with the capabilities of the computer, each midshipmen is assigned a computer if he does not have his own. It will be used in his studies and the familiarity of daily use will enable him to grasp the uses and capabilities of the technology quickly.

2. Current Information Systems

At the current time, the ROCNA has computer capabilities only in the library and a series of classrooms dedicated to computer training.

In the library, there is one small Ethernet LAN with six terminals and one server. This LAN is connected to Sun Yat-Sen University. This LAN is shown in Figure 18 and is a very low speed link across phone lines at 9600 baud.

The classroom Ethernet LAN is configured in a bus topology and includes 20 IBM PC compatible computers and a server. The configuration of the computers is identical and all computers share resources from the server. This LAN is shown in Figure 19.

This configuration is subject to a single hardware failure affecting the entire LAN system. This is very dangerous on a large system where many user are depending on the network for safety of there files and data. The situation is like a home cable system where failure seem to happen at just the wrong time.

3. User Survey

A survey was conducted to gather data about the current environment, personal attitudes and the users' requirements for a LANs at the ROCNA. The survey was designed to select a large population that would represent the user groups at the ROCNA. Its objectives were:

- To obtain quantitative data related to personal attitudes and the current information systems.

- To obtain quantitative data related to software requirements to meet organizational and personal needs.

- To obtain quantitative data related to the hardware requirements to meet organizational and personal needs.

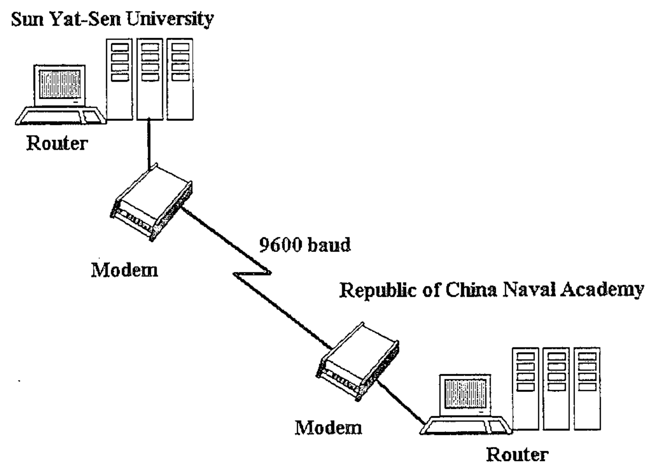

Figure 18. Library System.

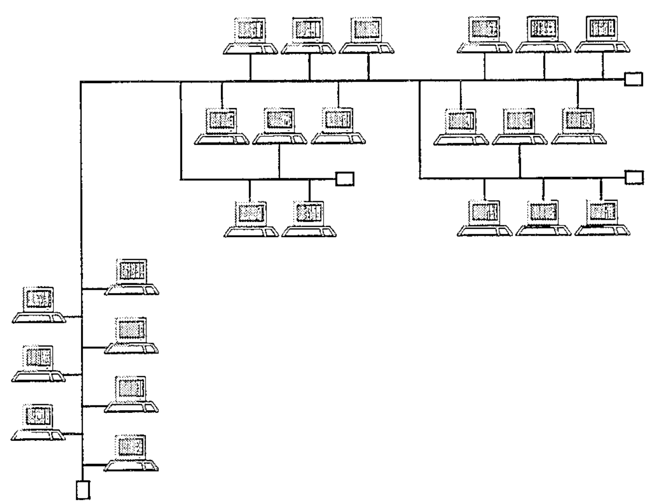

Figure 19. Classroom System.

To meet these objectives, the survey was distributed throughout the campus to five categories of potential end users. In the case of the ROCNA LAN, the customer is the Republic of China which has the objective of training and creating the very best Naval Officers with the additional concern that it is done economically and efficiently. The survey is directed at the users of the LAN. The users are concerned only with the efficiency of the system and its usefulness. The interface between the customer (ROC) and the user in the case of the ROCNA is done with the budget authority authorized by the customer. To summarize, the LAN must meet the users' requirements, but its cost must meet the budget authority authorized. In a commercial operation, the customer is usually the user of the product and makes decisions based on how useful the product will be. However, this is not always the case. For example, a parent buying a toy is the customer and the end user of that toy is the child. It is important to differentiate between the customer and user when preparing a survey because you cannot assume that the customer for any design has the same goals as the end user.

Table 9 is a breakdown of potential LAN users by category. Approximately 20 percent of the end users were surveyed. One hundred and thirty-five questionnaires were distributed and 112 were returned.

Category	**Total Members**	**Quantity Distributed**	**Quantity Returned**
Officer	272	35	31
Faculty	90	15	12
Employee	46	10	8
Student	629	50	39
Petty Officer	131	25	22
Total	1168	135	112

Table 9. ROCNA LAN Survey Distribution.

When designing the questionnaire, it was necessary to make the questions inclusive enough to cover the entire spectrum of users. These include students,

professors, administrative personnel and others who have very broad array of uses for computer technology. The survey questions are in Appendix A and the results are presented in Appendix B. The questions can be divided into four groups.

- Questions 1 - 3 are directed at determining the users knowledge of computers.
- Questions 4 - 7 are directed at determining the software requirements of the user.
- Questions 8, 9, and 12 are directed at determining the hardware requirements of the user and the necessary speed of the LAN.
- Questions 10 and 11 are used to determine whether the LAN is in fact necessary.

4. Results of the User Survey

From the 112 returned questionnaires, the following inferences can be made:

- Approximately 80 percent of the potential end users are currently using a computer and depend on computer/word processing resources. A small minority are using typewriters, dedicated word processors, or handwritten material.
- Software required for the end users includes: database management, programming languages, graphics, spreadsheets and the most common requirement is word processing. The majority of surveyed end users find personal uses for: word processing, electronic mail, spreadsheet, graphics and database management. Electronic mail is useful to 70 percent of the potential end users with 80 percent requiring only unclassified security for their mail.
- Hardware required for end users include: laser printers, dot matrix printers and a mouse. Up to 20 percent of the end users believe that a color printer and image scanners would also be useful.
- The surveyed users believe overwhelmingly that the LAN would be useful. 85 percent of the users believe they would benefit from the LAN and access to its resources.

In summary, most of the surveyed users believe they will benefit from a modern LAN and the LAN will support their requirements. Additionally, a small percentage of

users have not identified any use for the LAN. These users could be victims of the railroad paradox. Essentially, in the railroad paradox, a request is made for the railroad to stop at a station. The railroad goes to the station to see if there is any potential passengers for the stop requested, naturally, there are no passengers waiting for a train that is not making a stop and the railroad turns down the request because there are no potential passengers at the station. What this means in the case of the end users at the ROCNA is that some potential end users currently do not have access to computer resources and cannot visualize their potential use in solving the end users problems. Of particular interest in this area is electronic mail which many of the potential users will find useful in the daily activities of any academic organization.

C. DEFINE THE NETWORK REQUIREMENTS

In defining the networks requirements, various factors must be considered along with the results of the end user survey. These factors also will contribute to the final design of the LAN. The following is a list of factors which relate more to the customer's requirements, in this case, the ROC than the users' requirements:

- Does the users' requirement contribute to the objectives of the organization (ROCNA)?
- Does the LAN meet users' requirements?
- Did the survey elicit enough data to determine the users' requirements?
- Did the survey include enough potential end users to identify all end user problems?
- Does the budget authority exist to meet the end users' requirements?

By considering these questions and the results of the survey, a more detailed picture of the LAN requirements can be developed. The results of the survey and the considerations above, lead to the following inferences for the design of the LAN.

1. Customer Requirements

The customer is the organization that will purchase the LAN, and expects the LAN to meet long-term goals or strategies. The customer is providing a tool to the users to enable the users to accomplish the customer's long-term goals.

a. Long-Term Policies of the ROCNA

The Naval Academy expects to upgrade their information resources to the level of serving as a node for the proposed national Internet. This will help meet the goals of the ROC policy of networking the Island of Taiwan and the ROCs NII goals.

b. NII Policy Goals

To remain in the forefront of technological development and maintain its economic prowess, the ROC must establish NII to be competitive with the industrial nations of the world in the future. This goal is accomplished in two ways: the actual construction of the LAN and the training of the future leaders of the ROC in advanced information technologies.

c. Budget

The ROC has allocated funds to upgrade the Naval Academy's LAN. Like all governments, if the money is not used at this time to upgrade the LAN, it will have to be either reallocated at some future time or the opportunity may even be lost. The loss of the opportunity or delay would affect the other military academies. The intention is to connect those academies through the ROCNAs LAN and gateways to Sun Yat-Sen University and the proposed NII.

2. User Requirements

The users' requirements are associated with how well the LAN will meet their needs. Users differ from the customer in that the user has specific problems that they wish to solve.

a. Message Document Processing and Transmission

In order to reach the goal of office automation, sharing of resources and the integration of databases, the LAN must connect all campus buildings. The LAN topology should be flexible enough to accommodate future growth. This would indicate a token ring topology using a very high speed network such as FDDI between servers. Workstations should be connected using a star topology because this provides the ability to remove and add workstations without affecting the operation of that portion of the LAN. The workstation should be connected with very high speed links (100 Mbps) to provide for the future requirements of video transmission, multimedia, etc. If the LAN is built at this time, with older technologies and current trends continue, it will invariably have to be rebuilt with fiber-optic technology. The initial investment in the older technologies will then represent a waste of budget resources. For short runs in existing buildings, it is possible to use unshielded twisted pair in 100Base-T or 100Base-VG Fast Ethernet.

b. Functionality Considerations

The LANs should create a computer lab environment with a high capacity servers connected in a backbone providing resources to workstations. These servers should present a multi-user, multi-task operating system for both academic research and for use in the curriculum to train students. This could either be a UNIX system or possibly a multi-CPU Windows NT server. The protocol used should be TCP/IP and bulletin board services, electronic mail and other organizational software should be provided at the level of the servers.

Applications indicated in the survey can either be supplied at individual workstations or licensed from the servers and supplied to the limit of the license to the workstation. Individually required applications could be installed at the individual workstation to meet that end users needs.

c. Security Controls

Security concerns have two natures in the environment of the ROCNA. First, there is the security of classified information and second, there is the security of the systems configuration and operation. The security of classified information is usually provided for on a separate LAN which is physically separated and secure from the unclassified LAN operation. Information is allowed to flow from the unclassified LAN to the secure LAN but any information removed from the secure LAN must be copied manually and passed through all the normal routines of handling classified material. The second concern is the security of the system. The academic side of the LAN is under assault from the students and the experimental nature of research. However, the administrative side of the LAN is used for the daily work of the people who manage the school and perform the operations which interface the school to the outside world. The administrative side of the LAN, although not necessarily classified, should be operated in the same way as the military classified system would be. This would be the administrative side of the LAN can publish material to the academic side but there should be a restriction on the flow of requests for resources from the academic side to the administrative LAN.

D. SUMMARY

The results of the survey indicate that the vast majority of the potential end users will find the LAN useful and have existing problems which the LAN will solve. Computer technology is changing so fast that for the ROCNA to build a LAN that is not already obsolete when it is completed, it must use the very latest technologies available. These technologies include multimedia and video transmissions which should have useful applications in the environment of the Naval Academy. Although 77 percent of the surveyed end users have access to computer technology at the current time, the resources of electronic mail, laser printers and large databases are not available to them. These end users may not have a clear understanding of the impact of these technologies on solving

their problems. In summary, the LAN will be a useful asset to the Naval Academy and solve many problems for the end users which could not be identified with this limited survey.

IV. LOCAL AREA NETWORK DESIGN FOR THE ROCNA

A. INTRODUCTION

The systems design approach outlined in Chapter II, will be used for the physical design of the ROCNA LAN. The networks success may be determined by a single poorly designed element, either software or hardware. To ensure the success of the LAN, every element of the LAN should be analyzed before its purchase. (Fitzgerald, 1993)

A blueprint should be developed for the Naval Academy network that fulfills the requirements for efficiency, reliability, utility, is compatible with the operations of the Naval Academy and reaches all the potential end-users of the system.

The designer must balance all these factors and make some trade offs that will lead to a successful solution. The designer's approach to network design should also have a system perspective. This perspective encompasses other important aspects of the design, management, user training, compatibility, security, maintenance, and the documentation of all the elements that make the LAN hardware and software. Although it is difficult to find the perfect solution to meet all the design goals, the best way to approach the design is follow a step by step procedure that considers as many factors as possible.

Table 10 illustrates the step by step procedures to design the ROCNA network.

Step	Description
1	Conduct A Feasibility Study. Determine The New Network Requirements.
2	Identify The Geographic Scope.
3	Determine Network Configuration And Alternative Configurations.
4	Evaluate Hardware/Software Specifications
5	Calculate Networks Costs; Cost/Benefit Analysis
6	Implement Considerations.

Table 10. Network Design Methodology (Fitzgerald, 1993)

In Chapter 3, the feasibility study was conducted and a basic concept of the new system requirements was gained. The following sections will illustrate the remaining steps in the design of the ROCNA LAN.

B. IDENTIFY THE GEOGRAPHIC SCOPE

Geographic scope for a LAN design affects the selection of a network, hardware/software components, the design of its topologies, as well as the alternatives design evaluation. Depending on the geographic scope, the designer must limit their considerations to a specific design solution. For the designing of the LAN topology, the specifications of different network equipment and standards must be considered before the physical topologies were applied. For example, the FDDI network supports nodes up to 2 km apart with multiple-mode cable and up to 40 km with single-mode cable; FDDI network may support up to 1000 nodes on the network. With these limitations the designer can conclude that these limitations are satisfied and the FDDI standards can be met as they apply to ROCNA campus network. But the designer must keep in mind that the history of computers and telecommunication is characterized by equipment that seems to have unlimited capacity that becomes obsolete in only a few years. The FDDI network would be the core of the campus system and 1000 nodes limitation may be a serious problem in the future where very high capacity computers are readily available.

1. Physical Location

There are 21 buildings on the 2000 square meters campus of the ROCNA. Because there is an existed trench used for an old telephone system, the new network media can reach to every building and a significant saving in costs. Figure 20 is the layout of the ROCNA campus. In organizations the library is at the center of campus, and the campus can be divided into four sections: education area, administration area, office and petty office living area, and cadet living areas.

2. Identify Network Traffic

An analysis of the ROCNA survey and interviews indicates that the campus network traffic can be categorized into two groups: medium-low and medium.

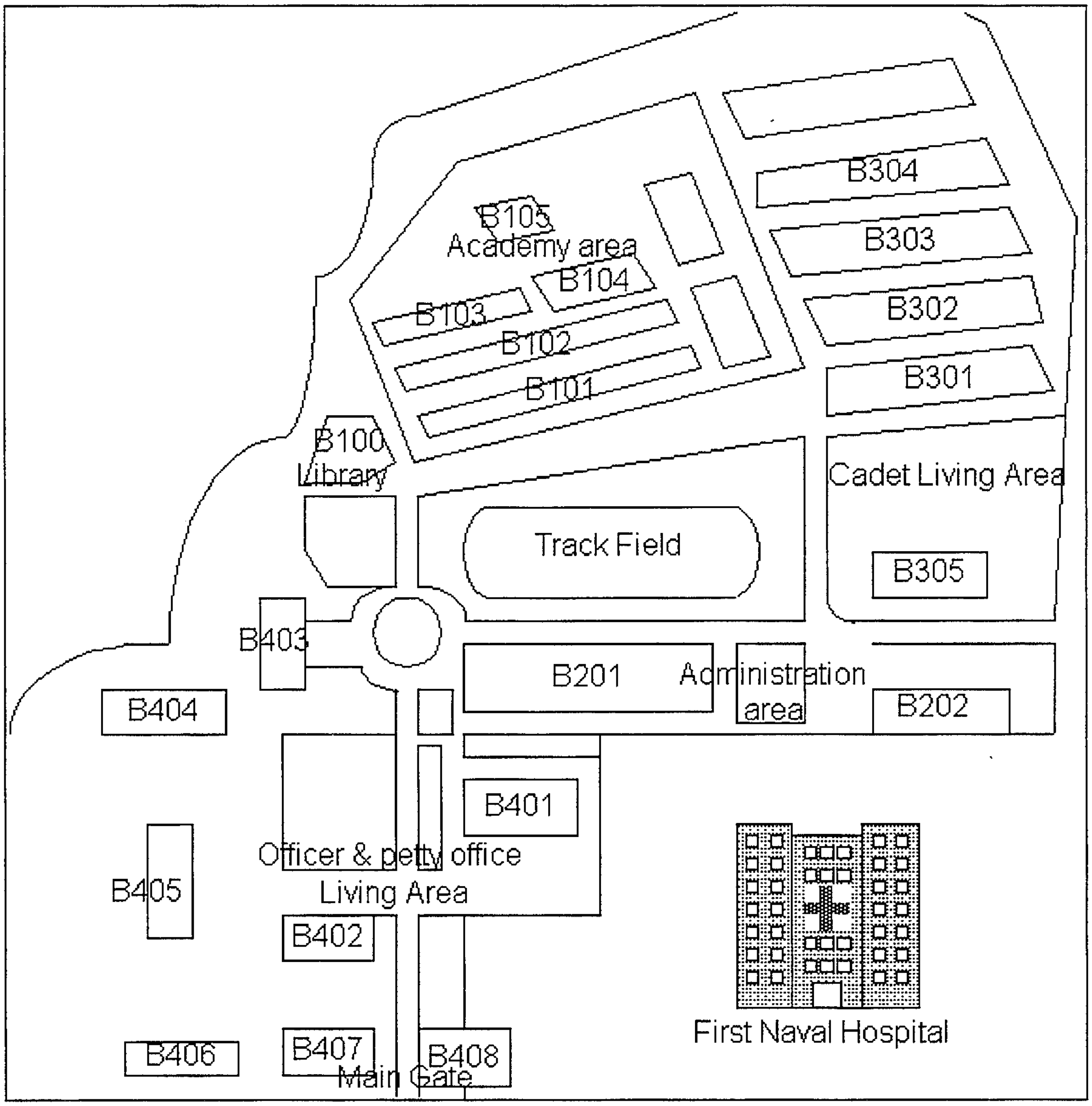

Figure 20. Map of ROCNA

a. Medium Network Traffic

The education area and administration area can be categorized in this group, including seven buildings. There are many stand alone PCs scattered throughout

these two areas, dealing with administrative paper work, and providing resources for students and the teaching staff. From the view point of the personnel interview and survey, this is the most important area of the campus where the LAN is to be built. The potential activities include E-mail, FTP, BBS, and WWW. This traffic will increase in time, and a medium network traffic capacity can be expected to be needed in the future.

b. Medium-Low Network Traffic

The office or petty office living area and cadet living area can be categorized as a medium-low traffic system. This area includes 13 buildings. From the view point of personnel interview and survey, there is a low level of computer activities in these areas now, but considering the potential future growth, network traffic should reasonably be categorized as medium-low.

3. Identify Network Security and Control

Although the purpose of ROCNA is primarily devoted to education activities and basic military training more then defense activities; it still is necessary to separate the administration areas and education areas. For example, by using hardware/software mechanisms to separate the campus network into an administration and academy network the administration network can share the resources of academy network, but academy network will not be able to use administrative resources necessary for the day-to-day operation of the school.

According to a market research report, computer virus, illegal intrusions, and unstable electrical resources are three main factors and threats to the security of network data. Additionally, natural disasters such as fire, flood, earthquake, lighting; poor environmental conditions, poor quality production; and human factors such as incorrect operation, incorrect procedures, etc. are the sources of most serious problems. In order to deal with this, the protection of information security can be divided into the following categories:

a. Hardware System Protection

- Always consider back up system
- Evaluate the power system before purchase or set up the hardware equipment
- Electrical and communication system consider to be grounded; power surge ; protect lighting equipment if necessary; quality of media (noise or jam will affect data transmission in network)
- Periodical maintenance contacts

b. Software System Protection

- Formal organization controls and administrates the network system.
- Administrator make a specific rules in order for the users to follow.
- Update the anti-virus software, actively keep track virus.
- Educate the users doing correct operation and follow the normal power on/off procedure; Establish users the good habit and concept in computer security aspects, such as password choosing and never share password with other.

c. Illegal Intrusions Protection

This kind of protection is difficult and needs lots of man power and money. But it is a important consideration if the LAN is built. The following methods are result in different security levels:

(1) Software Isolation. The first line of defense is using a network software in the router to block all the packet, which are not in the IP address for the server at administration subnetwork; The second line of defense is using the user ID and password to prevent an intruder from gaining access to the administration subnetwork.

(2) Hardware Isolation. Using two different media and NICs to separate administration network and academy network inside the campus. Only the academy networks can go through a router to TANet or Internet sharing the information with the outside world.

(3) Complete Isolation. Don't put the classify data on the network if it is not necessary for a network connecting.

(4) Using Separate Operating System And Protocol In Each Networks. For example, the academy network uses Unix operating system and the administration network uses Novell network system. Those two system can not communicate each other because using different protocol, and alos the outside campus users can not go into the administration network. (because TANet not open Novell's SPX/IPX protocol transmission.)

C. DETERMINE NETWORK CONFIGURATION

Before determining the standards and alternatives for a network configuration, we need to complete network design procedure and perform Steps 3 through Step 5 in Table 10. Network Design Methodology. Repeating these three steps for each part of the network configuration and evaluating the results until a good design is achieved. In other words, we design network configuration, evaluate software/hardware, calculate costs and then return to redesign to achieve some aspect of the design not fulfilled. For example, in the choice of the network layout, the layout depends on several other factors such as the right-of-way between building and existing trenches and wiring. If we may not be able to cross a public road or common area in order to make connection the layout must be redesigned. The first step in process is viewing the map (Figure 20) that shows the links between the station/node locations, reviewing the network requirements we discussed in Chapter 3 and comparing these to the goals of network design in the following:

- Minimum circuit mileage between the various stations/nodes. (Using the old telephone trench can reduce cost if the trench is suitable.)
- Adequate circuit capacity to meet today's data transfer needs, as well as the requirements three to five years in the future.
- Reliable hardware that offers minimum cost, adequate speed and features, a high Mean Time Between Failures (MTBF), and good diagnostic and serviceability features.

- Efficient software/protocol that can be used on a variety of circuit configurations. One of the newer High-level Data Link Control (HDLC) protocols that can operate with various international standards, such as X.25, could be used.

- A very high level of reliability (network up time) must be met.

- Reasonable costs (but not necessary the absolutely lowest).

The following consideration of media and topology standards for the network configuration will be created:

- NII perspective: High bandwidth and high capacity media; like FDDI, 100baseT or 100baseVG that can reach above 100 Mbps transfer rates.

- Reliability and security: Logical ring will be more reliable than star or bus; Fiber optic will be more security than coaxial or twisted pair.

Therefore, the candidates for network standards from the tentative configuration of the campus network are as follows:

- Dual ring FDDI backbone that connects 21 buildings as a star topology;

- According to the geographical scope, we divide 21 buildings into four segments, academy area (A1), administration area (A2), student living area (A3), and office or petty office living area(A4) that are connected to the FDDI backbone. (Figure 21 shows the configuration)

- Inside each building, there are two LANs topologies to consider; IBM token-ring and or Ethernet network.

D. EVALUATION OF SOFTWARE/HARDWARE

The purpose of this step is to evaluate the details of the software and hardware elements which will be used to construct the LAN at the ROCNA. A hardware/software purchase list will be present to be used for a cost analysis of the LAN.

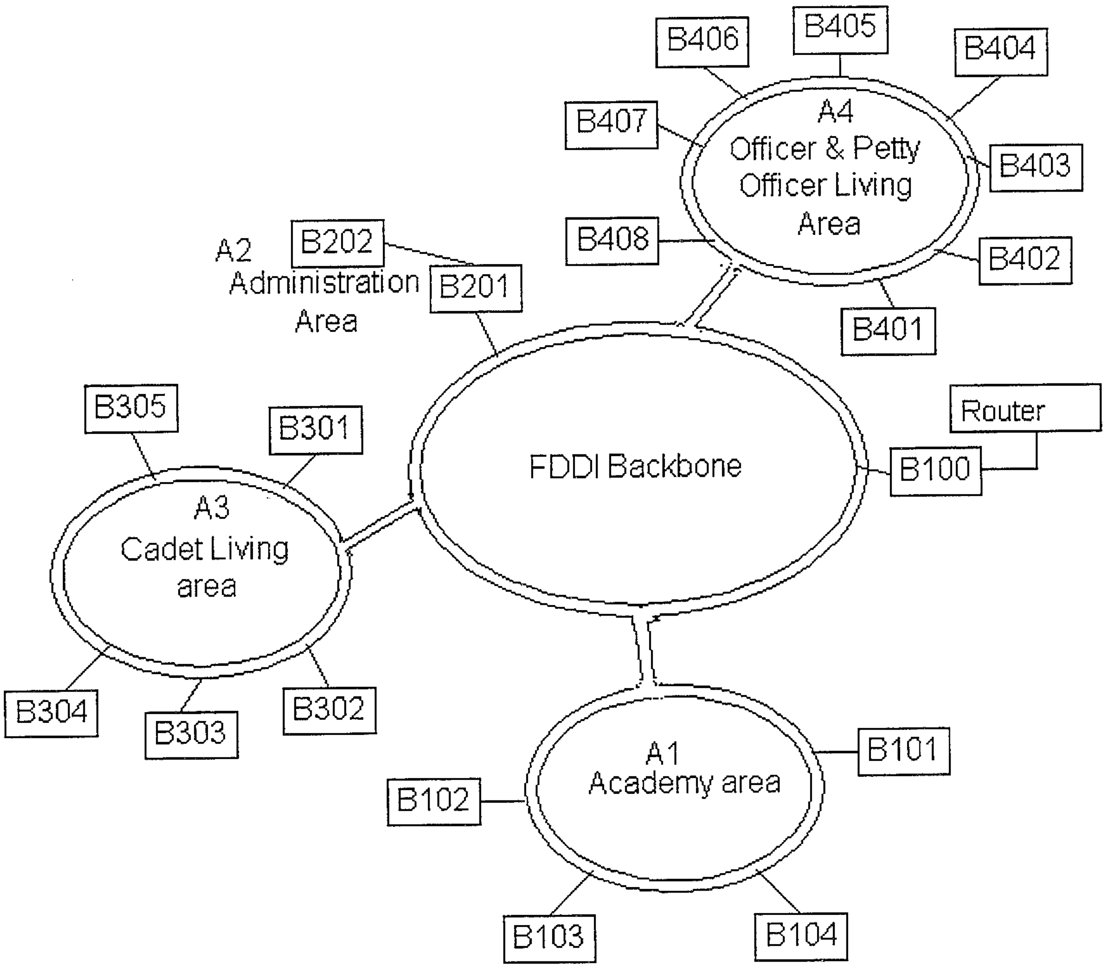

Figure 21. ROCNA Campus Network Topology

1. Software Selection

Software lists should identify the software required to support networking, internetworking, and functionality applications. For example, disk operating systems (DOS), network operating systems (NOS), internetworking software, network management software, and security software. Some applications package have a combination of functions serving as networking, internetworking, management and

security function. For example, NOS software provides networking, internetworking, and security function abilities. Some software is supplied with hardware when purchased. For example, a hub or network switch may provide the ability of network management. Basically, we must have a PC operating system like DOS, or for Windows application, Windows 3.1 or Windows 95, or a network operating system (NOS), Windows NT or NetWare 4.1, to allow PCs clients to communicate with other clients or servers working. They must use common protocols, like TCP/IP or IPX/SPX, for them to communicate with each other or sharing data and resources.

In the networking and internetworking software's selection, we must at least have DOS 6.2, Windows 3.1, on PC clients and NetWare 4.1 or Windows NT 3.5 for the network operating system using the TCP/IP, IPX/SPX protocols for internetworking. In application software's, for the network to be useful the design must provide for the end-users requirements of Database Management, Programming Languages, Spreadsheets, Word Processing, and E-Mail application.

Because some software may be for the use of specialized hardware or involving applications that are not of critical importance in the design of the LAN and will have no influence of the network topology, this type of software is not included in the cost analysis.

In general most current software will work with any reasonable operating system implementation of the networking software. There still exists the problem of users who have become familiar with a favorite program and will not switch to a more current operating system because the design of this program is not compatible with the new operating system. There is also the equivalent hardware problem where a useful piece of equipment cannot be used on a new operating system because the manufacture has not updated its specialized software.

These problems are the result of the economics of computer hardware and software. A manufacturer has less incentive to update the software for a product that he

has already sold then to track the most current operating systems in hope of increasing sales to customers buying new systems.

In summary, software other then the word processor, spreadsheet, groupware and database variety is a cost benefit analysis problem for the end user of that application and does not have a measurable effect on the overall design of the ROCNA LAN.

2. Hardware Selection

Hardware selection is a simpler problem than software selection because hardware is tangible and has a measurable function and purpose. The hardware list should include all the components required to support the network or internetwork operating on LAN of ROCNA. For example, stations (nodes), printers, servers, NICs, media, connectors, hubs, switches, bridges, and routers. We are not going to include the selection of computers and printers because these exists in most of buildings. Hardware selection is divided into the following categories for analysis.

a. Building Network

There are 21 buildings (subnetworks) inside Naval Academy campus network. The considerations for the hardware components is dependent upon how many nodes per building and how wide available a network connection will be inside the building.

In the nodes distribution, we assume every building has 24 nodes with a total 500 nodes for all buildings on the campus. There are two common LAN's topologies used in the building of the campus. They are token ring and Ethernet networks.

In the token-ring network, the components include token-ring network interface card (NIC), cable, multistation access units (MAUs), and connectors. Every node must have one data connector connect the MAU and one PC adapter cable connect to workstation. Two data connectors and one patch cable connect between MAUs. The Figure 22 show the token-ring network layout.

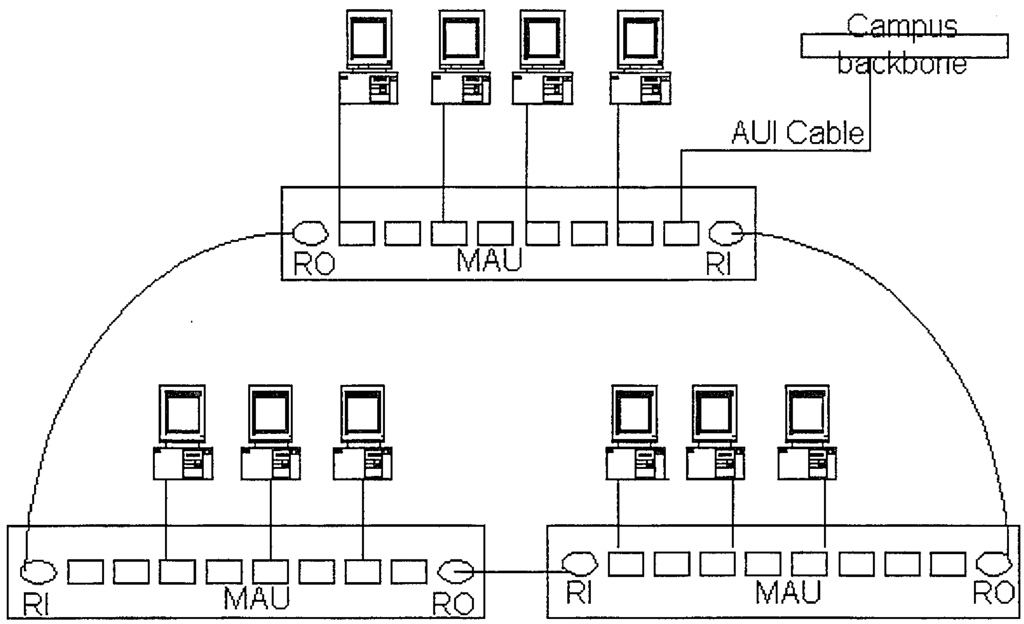

Figure 22. Token Ring MAUs
After [Feibel, 1995]

There are restrictions and limitations between token-ring network components as follows:

- Maximum lobe length (the distance between node and a MAU) is 100 meters for STP; 45 meters for UTP.
- Maximum ring length (the distance between MAUs on the main ring path) is 200 meters for STP; 120 meters for UTP.
- At most, 260 lobes allow on the network for STP; 72 lobes for UTP;
- At most, 33 MAUs are allowed on the network.

- At most three cable segments (separated by repeaters) are allowed in a series.

Bus and star are the two common topologies used in the Ethernet network. In a star topology, usually using twisted pair, the nodes are attached to a central hub. In a bus topology, usually using coaxial cable, the nodes are connected to the network's backbone with thin Ethernet by a T-connector. The twisted-pair (10BaseT) Ethernet networks are quite popular and used by most people because they are simple to install and the special purpose hubs have been enhanced with various capabilities and features such as, network monitoring and management, security features. In this study, the focus is on twisted-pair Ethernet, it's components include the Ethernet NIC with on-board Medium Attachment Unit (MAU), UTP cables, RJ-45 connectors, punch-down block and hubs. Figure 23 shows the 10BaseT Ethernet network layout. There are restrictions and limitations for 10BaseT network components as follows:

- Maximum segment (distance between nodes and hub) length is 100 meters. (Using UTP with RJ-45 connections at each end)
- Maximum nodes per segment: 512
- Maximum nodes per network: 1024
- Maximum hubs in a chain: 4

The different LAN topology has their own components for the construction of a LAN. Table 11 shows the costs and all components using 10BaseT or token-ring LAN for one building with a 24 node network. (Gobal DataCom catalogy, 1996)

The author's research shows that the cost of using token-ring topology is 2~3 times that of the cost of using Ethernet topology.

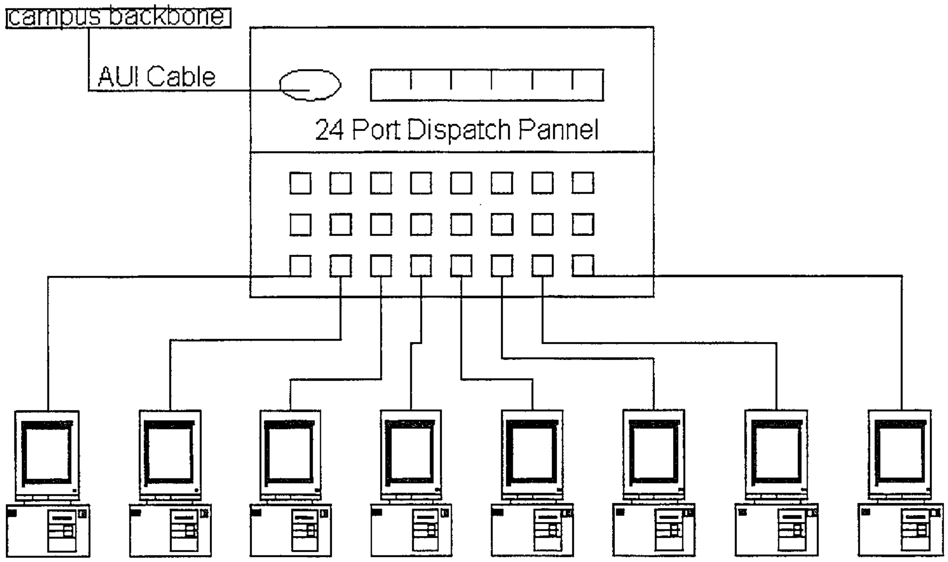

Figure 23. Ethernet MAU

b. Backbone Media Selection

The backbone of the campus LAN will extend the LAN connection to every building. Its cost is dependent on the distance between each building. Because the network traffic conditions, we divide all buildings into 4 segments: A1, A2, A3, and A4. Their layout and relationship are shown in Figure 24. The backbone media can use fiber optic, coaxial, and twisted pair cable. Table 12 shows the cost using each media for the network backbone. Table 13 shows comparison of the factors of three media; compare cost, installation, capacity, attenuation, EMI and users. Although the cost of fiber optic is a little higher than the others, the performance and future growth consideration make fiber optics the best choice.

c. Connectivity and Interconnectivity

A major point to consider for the connectivity of all buildings to the network backbone is to maintain the networks survivability and performance. From the

designer view, the logical topology is easy to conceptualize, developing the physical topology and layout is more difficult. It is difficult to come to a balance between costs, survivability and performance. It is important to examine these considerations, balance them and make tradeoffs to achieve an acceptable solution.

Token Ring				
Component	**Item**	**Quantity**	**Cost**	**Total**
NIC	SMC - Token Ring Cards	24	$219	$5,256.00
MAU (HUB)	8 Port STP	3	$379	$1,137.00
Cable	Patch Cable (8 ft.)	16	$29	$464.00
	Patch Cable (35 ft.)	8	$39	$312.00
	Patch Cable (75 ft.)	3	$49	$147.00
Connector	Data Connector	32	$10	$320.00
	PC Adapter Cable	24	$19	$456.00
			TOTAL	**$8,092.00**
Ethernet				
Component	**Item**	**Quantity**	**Cost**	**Total**
NIC	3COM Etherlink III,	24	$80	$1,920.00
MAU (HUB)	SMC TigerHubs:			
	EtherEZ Hub-8	1	$200	$200.00
	EtherEZ Hub-16	1	$390	$390.00
Cable	STP (1000 ft.)	1	$259	$259.00
	UTP (1000 ft.)	1	$139	$139.00
	Thin (1000 ft.)	1	$429	$429.00
	Thick (1000 ft.)	1	$599	$599.00
Connector	RJ	48	$2	$ 96.00
	T	24	$6	$144.00
	BNC	24	$2	$ 48.00
	BNC Terminator	2	$4	$ 8.00
		UTP	**TOTAL**	**$2,745.00**
		STP	**TOTAL**	**$2,865.00**
		Thin	**TOTAL**	**$3,139.00**
		Thick	**TOTAL**	**$3,309.00**

Table 11. Token Ring and Ethernet Cost

Because the buildings are spread over the campus, it is not practical and not economical to lay out the fiber optic cable from the central of hub to each buildings. From a survivability and costs view point, there are two type of connections to the backbone: Type I uses concentrators connect to all the buildings and because a FDDI dual ring backbone, has the wrapping function to reconfigure it if a link fault occurs. The

connection lay out show in Figure 33; Type II is base on a point to point connection; it rings all the building and using routers at some buildings with heavy traffic in order to improve the token time flow over the entire ring. Table 15 show the details of all the components and costs for this two type of backbone connectivity. Apparently, a Type I backbone is twice as expensive as Type II.

Segment	Building	Range (m)	24 O/F (3.04$/ ft.)	Coax Cable (319$/500 ft)	TP (139$/500 ft)
A1 (Academy Area)	101	340	3100	650	283
	102	100	912	191	83
	103	180	1642	344	150
	104	200	1824	382	166
	105	310	2827	593	258
A2 (Administration Area)	201	580	5290	1110	483
	202	230	2098	440	191
A3 (Student Living Area)	301	490	4469	937	408
	302	170	1642	325	141
	303	240	2189	459	200
	304	300	2736	574	250
	305	230	2098	440	191
A4 (Officer Living Area)	401	520	4742	995	433
	402	350	3192	669	291
	403	470	4286	899	391
	404	270	2462	516	225
	405	240	2189	459	200
	406	190	1733	363	158
	407	170	1550	516	141
	408	470	4286	899	391
	Totals	**6050**	**55267**	**11761**	**5034**

Table 12. Backbone Media Cost

In the interconnectivity aspect, the ability of a connection to NSYS university (a node of TANet) already existed. It is a 9.6 kbps data rate digital dedicated line leased from the telephone company. This low speed's modem is even slower than current PC modem speed (28.8 kbps speed of modem are very quite common) and is not going to satisfy the current users who wish to surf the internet, to say nothing about future

users. It is necessary to replace the dedicated line with one that can operate with speeds of at least 56 kbps.

Factor	O/F Cable	Coaxial Cable	TP Cable
Cost	Highest	Moderate	Lowest
Installation	Difficult	Fairly easy	easy
Capacity (Mbps)	45 ~ 100	10 ~ 20	1 ~ 16
Attenuaiton Range (Km)	Lowest 2 ~150	Lower 1 ~ 30	High 0.1 ~ 2
EMI	Immune To EMI, RFI	Subject To EMI	Subject EMI
Users	• FDDI Networks • To Connect Networks • To Connect High-Speed , High-Performance Workstations	• Ethernet Networks • Cable TV Lines	• IBM Token-Ring Networks • Ethernet Networks

Table 13. Comparison of Backbone Media

Type I (FDDI backbone)				
Component	**Item**	**Quantity**	**Unit Cost ($)**	**Total**
Concentrator	Start Kit - Fible	6	9,995	59,970
Connector	62.5/125, MIC connector	2 x 6	225	2,700
	SC to MIC connector	2 x 6	220	2,640
Modules	O/F 4-port & MICs	6	3,095	18,570
Adapters	FDDI-EISA Fiber 32-bit	12	1,745	20,940
Transciver	NX-300 Series FOT	21	100	2,100
			Sum	106,920
Type II (Point to Point)				
Component	**Item**	**Quantity**	**Cost ($)**	**Total**
Router	CISCO Router 7513	1	42,000	42,000
Connector	62.5/125, ST connector	24 x 20	8	3,840
	Fan out Kit	20	100	2,000
Transciver	NX-300 Series FOT	21	100	2,100
Distribution Equipment	24 Port Patch Panel	21	302	6,342
			Sum	56,282

Table 14. Components and Cost of Backbone

3. Maintenance And Training Consideration

After the network is built, the issue of maintenance, survivability and performance, maintenance costs, the cost of training or educating users and administrators of the system will become primary concerns for the LAN's customer the ROC Navy and the ROC. Cost at this stage are intangible and difficult to identify. The operations of a LAN is little studied and its cost analysis is victim to rapidly changing technologies and the unique nature of each LAN system. This study will not address these costs.

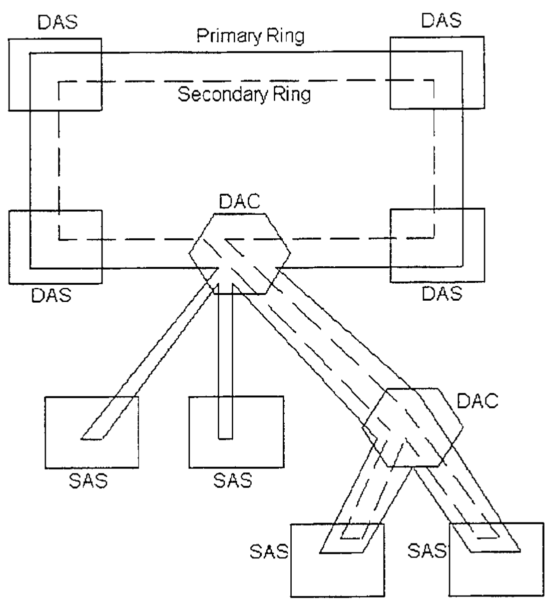

Figure 24. FDDI Backbone

E. CALCULATE NETWORK COSTS

Usually, it is poor procedure and limits creativity to consider cost limitations during development of design alternatives. Of course, an effort should always be made to keep the costs down; however, costs should not interfere with the preliminary design

keep the costs down; however, costs should not interfere with the preliminary design configuration and its alternatives. The point is that the various alternatives should be identified first; then costs should be related to an attainable design configuration. The first task is to identify the attainable and workable configurations, and the second is to identify the costs of those alternatives.

1. Identify Network Cost

Estimating the cost of a network is much more complex than estimating the cost of a single piece of hardware. Many variables and intangibles are involved. Nevertheless, estimating the cost of network is a necessary prerequisite to deciding whether its implementation is justifiable. There are several major cost categories for the entire network that must be included. For example, circuit costs, hardware/software costs, test and maintenance costs, and network management costs. Some costs are intangible and difficult to justify. Some software costs or test and maintenance costs are included in the hardware costs when a contract is let. Therefore, the hardware costs are the only costs that will be identified in this study. There are several combinations that can form into different alternatives. For example, there are two types of LAN for the buildings, two kind of media for backbone, and of course this will create four different solutions for the network. Table 15 shows the alternatives for the campus network costs for several solutions in different combinations.

There are too many solutions formed by the combination of those elements. In this study the author picked some reasonably alternatives to compare the network hardware costs for different solutions.

2. Costs/Benefit Analysis

The purpose of costs/benefit analysis is to provide a method to filter all alternatives and choose a reasonable good solution. Each alternative will reflect its own cost; usually the low cost's solution will be the candidate. The different alternatives also will create their own advantage or disadvantage and the advantages may override the factor of lower cost. It is important to bring into balance all factors of costs/benefit that

will affect the final solution. The following analysis will separate the campus network in two parts, buildings LAN (subnetworks) and the backbone connection. For the purpose of discussion of different factors in costs and benefit and their impact on various alternatives.

Building			Backbone	Connectivity		
	Token Ring	**Ethernet**	**O/F**	**Type I**	**Type II**	**Total**
I		$2,745	$55,267		$56,282	$114,294
II	$8,092		$55,267		$56,282	$119,641
III		$2,741	$55,267	$106,920		$164,928
IV	$8,092		$55,267	$106,920		$170279

Table 15. Network Cost for Different Alternatives

a. Subnetworks

There are two kinds of subnetwork topology used in the campus network, token-ring and Ethernet. In respect to cost the LAN portion that is token-ring topology is 2~3 times as expensive as the Ethernet topology. The least expensive alternative Ethernet is 10BaseT using UTP media. (See Table 11) On the benefit side, token-ring topology is superior to Ethernet topology in several aspects. For example, token-ring networks can support up to 16 Mbps speed, 10 Mbps for Ethernet; token-ring network allow 72 ~ 260 nodes (stations) in a single segment, but only 30 ~ 100 nodes for Ethernet (coaxial cable only); token-ring network can still maintain certain performance if the network is in the moderate or high load, but the performance for Ethernet network will go down apparently. But when the network is in a low load situation, the Ethernet topology will do a better job than token-ring topology (See Table 16).

According to this analysis, the rules of consideration can be made as follows:

	Cost	Delay For High Load	Delay For Low Load	Nodes/Segment	Speed
Token Ring	169428	Less delay	fair delay	72 ~ 260	16 Mbps
10BaseT(UTP)	57645	More delay	Less delay	up to 512	10 Mbps
10Base2	65919	More delay	Less delay	up to 30	10 Mbps
10Base5	69489	More delay	Less delay	up to 100	10 Mbps

Table 16. Cost/Benefit Analysis

- If the network traffic is in high load and the nodes in a single segment are over 100, token-ring and 10BaseT are the choices for the network topology.
- If the network traffic is in high load and the nodes on a single segment are between 72 to 100, there are there choices, token-ring, 10BaseT and 10Base5 Ethernet network, can be considered.
- If the network traffic is low load and the nodes in a single segment are under 30, then all the choices can be considered. For the reasons of costs and easy installment, the UTP Ethernet network would be a good choice.

Most all buildings on the naval academy will not exceed 30 nodes. Accordingly, the traffic in most of the buildings is not high load and the nodes are not greater then 30. Therefore, the weighting is for UTP Ethernet network topology. Besides, this topology also have virtues of low cost, easy installment.

b. Backbone and Connection

The cost of different backbones and connection components are shown in Table 11. On the costs aspect side, the O/F backbone and type I connection are more expensive than the others. But cost is not the only criterion to make a decision. In the benefit aspect side, there are many good points for using fiber optic cable rather then coaxial or twisted pair cable as the campus networks backbone. For example, high data rate, high capacity, high quality, more security, and the most important point is that it meets the customer's requirements. In other words, a backbone using coaxial or twisted pair cable in a very short time will no longer satisfy the newer network requirements, like the popular internet World Wide Web (WWW), video conferencing, or long distance learning. If we must spend a certain amount of money to build a network. Why not spend

instead of building a network that only can satisfy near future needs and require another investment later.

3. Network Alternatives

Recently, the armed forces have been facing the prospect of downsizing of defense budget and organization downsizing. Demanding large amounts of budget are really a problem in military facility construction. Especially a one time budget authority to complete a million dollar project like campus network at the Naval Academy. In this environment it is better to separate the budget authority into several stages based on a task priority. Instead of making a one time investment, an alternative may be considered; first establishing the connectivity of all the subnetworks (buildings) using the fiber optic backbone and interconnectivity to out side campus; the high priority subnetworks such as the buildings in administration, academy area, and the UNIX workstation in the information center (library) can be built first and the other buildings can wait for further budget. Of course, all the software, application, and management programs to keep the network in operation and survivability should be considered as a high priority.

F. IMPLEMENT CONSIDERATIONS

The implement of network is the next step after the decision maker comes up with an appropriated network solution. This is probably the most difficult task of all because the various pieces of hardware, software/protocol programs, network management/test facilities, and communication circuits must be assembled into a working network.

1. Implementation Process

The implementation process begins when management has agreed to design the LAN and budget authority is obtained to purchase the hardware and software required. This stage of the design process requires the coordination of large numbers of people with many different specialties and skills.

To successfully accomplish this stage requires a detailed implementation plan with a step-by-step procedure for: the installation of equipment and software, testing,

specifications, training and qualification specifications, and the documentation of all stages of the installation for the later maintenance of the LAN system.

As much as possible, automated techniques using small computers should be used in the planning. Additionally, efficiencies can be gained by installation personnel visiting sites where like equipment has been installed. Training for end-users can also commence before the actual system is implemented.

The acquisition and lead time of all hardware and software should be tracked scrupulously to ensure that the project is not brought to a complete halt over some inexpensive connector or system software. To do this, the project team should maintain lists of alternate suppliers.

2. Evaluating the Operating Network

The last step in the design process is the evaluation of the network and its final implementation. This step requires in place procedures for tracking user complaints and requests for resources. The installation of the users software on the network is an ongoing procedure that requires training of both the personnel who service the network and the end-users. Most manufacturers upgrade their hardware and software to fix bugs or add features over time. It is necessary to document the ever changing configuration of any large system in order to reduce the long-term cost of its operation.

G. SUMMARY

This chapter has presented an outline of how to implement a network at the ROCNA and drawn conclusions as to what hardware would be the most beneficial. In a real world situation, this planning and implementation would involve many people who collectively produce the best system. Management of this design process would be to collect and synthesize the input from these people into a detailed plan for the implementation of the LAN.

V. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this thesis was to demonstrate the application of academic theory using the campus network in Naval Academy of ROC as a case study. The synthesis of theory, from system analysis and design, networks technology, and data communication provided the foundation for the multidisciplinary approach used in this study. Using the system design method and system development life cycle as tools of systems analysis to enable the designer to produce the analysis and design a working system. Applying network modeling concept to select the most cost effective alternatives for the design.

Using the step-by-step network design procedure; first, a feasibility study on Naval Academy of ROC was conducted to determine users and customers of the new network requirements. A review of the military doctrine, mission or function of organization was accomplished through personal interviews, a survey, and background research. Second, the geographic scope; including physical location, network traffic, and network security and control was determined. Third, a network configuration and alternative configurations were developed. Fourth, an evaluation of hardware/software specifications; with the focusing on the hardware, network components inside the buildings, backbone, and connectivity was performed. Fifth, network cost was calculated; using the cost/benefit analysis to decide on the final solution for the network layout. Finally, in summary the implement considerations; including an implementation process, evaluating of the operating network was outlined.

A. CONCLUSIONS

Local area networks play a very important role in national information infrastructure (NII) and also in internetworking. A local area network design should meet the needs of an organization and also should meet the customer requirements. The author has come to the following conclusions:

- A specialty team or group must be established before designing the network. This team should conduct the feasibility study of the organization; determine the requirements by reviewing the military doctrine; examining the mission or function of the organization, conduct background research, conduct the personal interviews and develop and conduct the user survey.

- A detailed plan and schedule for the designing and implementation of the network must be developed. This plan should include projected completion times, training schedule, who is to do what, when it is to be done, who is to decide or approve elements of the design and implementation.

- Although this study did not address the cost of application software for the network and the maintenance and administration cost after the network is built these costs are important. Though these costs are intangible and difficult to measure in a cost/benefit analysis, they are important to the maintenance, serviceability and uptime of the network. Experience has demonstrated that almost half of the costs network will be from this source.

- Network management and maintenance is an important issue after the network is established. This kind of task must be done continuously and will most directly affect the end-user of the system.

B. RECOMMENDATIONS

The potential of TANet and the Internet are unlimited. The ROCNA will lose much more than it will gain from just considering defense security. Networking will stimulate improvement in Information Technology (IT) level of the ROC and ROCNA. Information is the future world currency. A solid foundation in IT must be established, in hardware or software but also in the skills of people. The following recommendations are made:

- IT concept must be emphasized: Some high rank officers and government officials place more emphasis on weapons procurement than the IT technology. But as recent conflicts have shown information is a vital commodity. Without information and communication the largest forces cannot be effective. In the Persian Gulf War C^4I was used by the allies and IRAQ with its information system destroyed was forced to fight a World War I style defense.

- A formal or informal IT organization should be established to encourage the use, training and standardization of IT technology.

- Network specialty training should be provided to staff officers and students so that the network system installed will remain current.

- A number of IP addresses should be provided for the ROCNA. The ROCNA will serve as a router for the other military academies in the ROC and through a single IP address this may become a problem in the future.

- Network security is of particular concern to the security people of any military force. If security people were well trained in IT technology, it would not only alleviate these concerns, but improve the security of the military systems used in the ROC.

APPENDIX A. SURVEY

****

Naval Academy of the Republic of China
Local Area Network (ROCNA)
Requirements Survey

****

This survey is being conducted to help evaluate the automation requirements for the Naval Academy of the Republic of China. Your answers will assist with the development of a Local Area Network (LAN) to serve both students and faculty. Please be as specific as possible in answering all questions and feel free to expand on any answers given. Your assistance in completing this questionnaire is appreciated.

<u>Questions:</u>

1. Survey completed by a: (please circle one)
   a. Officer　　　b. employee
   c. Faculty Member　　　d. Student
   e. Other:

2. Do you currently have access to a computer?
   a. Yes　　　b. No

   If yes, what hardware and software do you use?

3. How do you most often compose written document?
   a. Hand written　　　b. Typewriter
   c. Word processor　　　d. Personal computer with word processing capability
   e. Other

4. What kind of software do you want in the lab to support teaching or course assignments? (Check all that apply)

a. Simulation
b. Decision Support
c. Database Management
d. Programming Languages
e. Computer Aided Design
f. CASE Tools
g. Graphics
h. Spreadsheets
i. Word Processing
j. Calendar/Scheduling
k. Electronic Mail
l. Message Encryption
m. Other

5. What kind of software do you want to support your personal applications? (Check all that apply)

a. Simulation
b. Decision Support
c. Database Management
d. Programming Languages
e. Computer Aided Design
f. CASE Tools
g. Graphics
h. Spreadsheets
i. Word Processing
j. Calendar/Scheduling
k. Electronic Mail
l. Message Encryption
m. Other

6. Do you need to send/receive electronic mail?

a. Yes
b. No

If yes, with whom do you need to communicate? (For example, other buildings on campus, a specific command, the World Wide Web, etc.)

With whom would you like to communicate?

7. For what security classification levels do you require communication? (Check all that apply)

a. Unclassified
b. Confidential
c. Secret
d. Top Secret

8. Do you need access to a:

a. Laser Printer
b. Dot Matrix Printer
c. Color Printer
d. Scanner
e. Mouse
f. LCD Panel
g. Other:

9. Approximately how many pages will you print per week?
   a. 0 to 50 b. 51 to 100
   c. 101 to 200 d. 201 to 250
   e. More than 251

10. If a LAN was installed so that you had a PC and access to the hardware/software listed above, would you consider this is a benefit?
   a. Yes b. No c. Maybe

11. If such a system was implemented, would you use it?
   a. Yes b. No c. Maybe

12. How often do you think you will plan to do certain activities (e.g., file transfer, send e-mail, use word processing, etc.)?
   a. Very often b. Often c. Not too often
   d. Seldom e. Never use

Thank you for completing this survey. If you have any other comments or suggestions, please use this area to list them.

APPENDIX B. SURVEY RESULTS

Question	# of Distribution	# of Responses	Mean
# 1	135	112	
1a	35	31	0.28
1b	10	8	0.07
1c	15	12	0.11
1d	50	39	0.35
1e	25	22	0.19
# 2	135	112	
2a		86	0.77
2b		26	0.23
# 3	135	112	
3a		27	0.24
3b		6	0.05
3c		3	0.03
3d		79	0.71
3e		0	
# 4	135	112	
4a		13	0.12
4b		14	0.13
4c		63	0.56
4d		50	0.45
4e		24	0.21
4f		17	0.15
4g		61	0.54
4h		43	0.38
4i		86	0.77
4j		29	0.26
4k		79	0.71
4l		16	0.14
4m		0	
# 5	135	112	
4a		5	0.04
4b		0	
4c		62	0.55
4d		20	0.18
4e		14	0.13
4f		12	0.11
4g		54	0.48
4h		61	0.54
4i		92	0.82
4j		39	0.35

Table 17. Questionnaire

Question	# of Distribution	# of Responses	Mean
4k		66	0.59
4l		3	0.03
4m		0	
# 6	135	112	
6a		77	0.69
6b		35	0.31
# 7	135	112	
7a		74	0.66
7b		17	0.15
7c		9	0.08
7d		0	
# 8	135	112	
8a		88	0.78
8b		52	0.46
8c		20	0.18
8d		27	0.24
8e		94	0.84
8f		0	
8g		0	
# 9	135	112	
9a		37	0.33
9b		18	0.16
9c		28	0.26
9d		10	0.09
9e		10	0.09
# 10	135	112	
10a		89	0.79
10b		8	0.08
10c		19	0.17
# 11	135	112	
11a		89	0.79
11b		8	0.07
11c		17	0.15
# 12	135	112	
12a		27	0.24
12b		43	0.38
12c		34	0.30
12d		6	0.05
12e		1	

Table 17. Questionnaire Continued

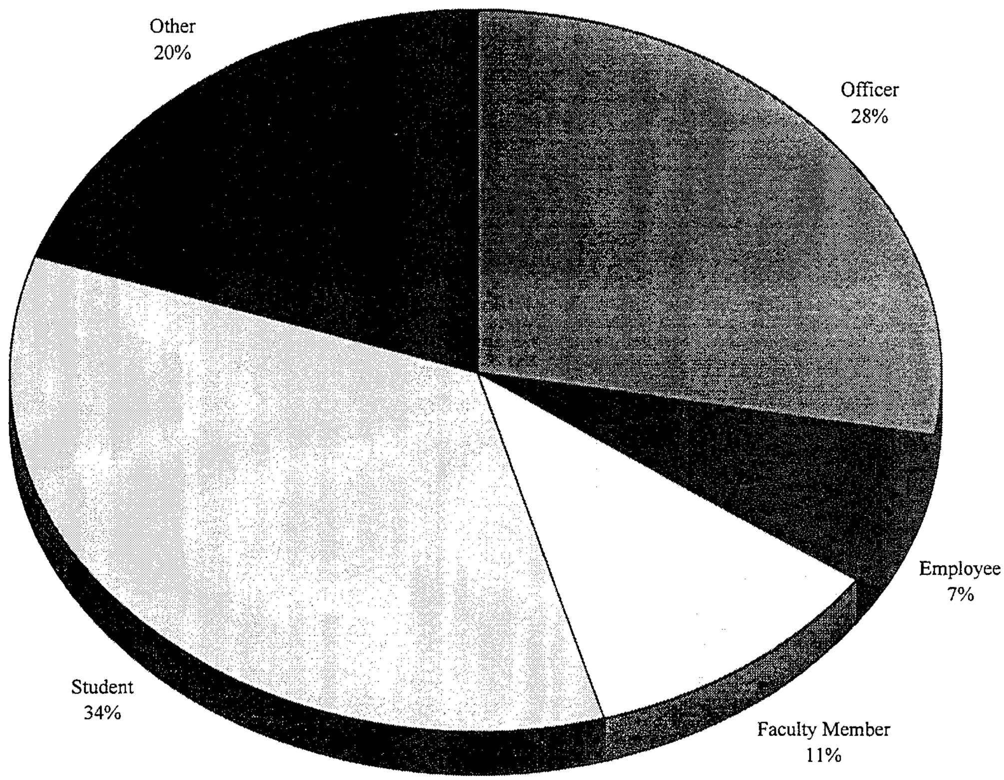

Figure 25. Question 1, Survey Distribution.

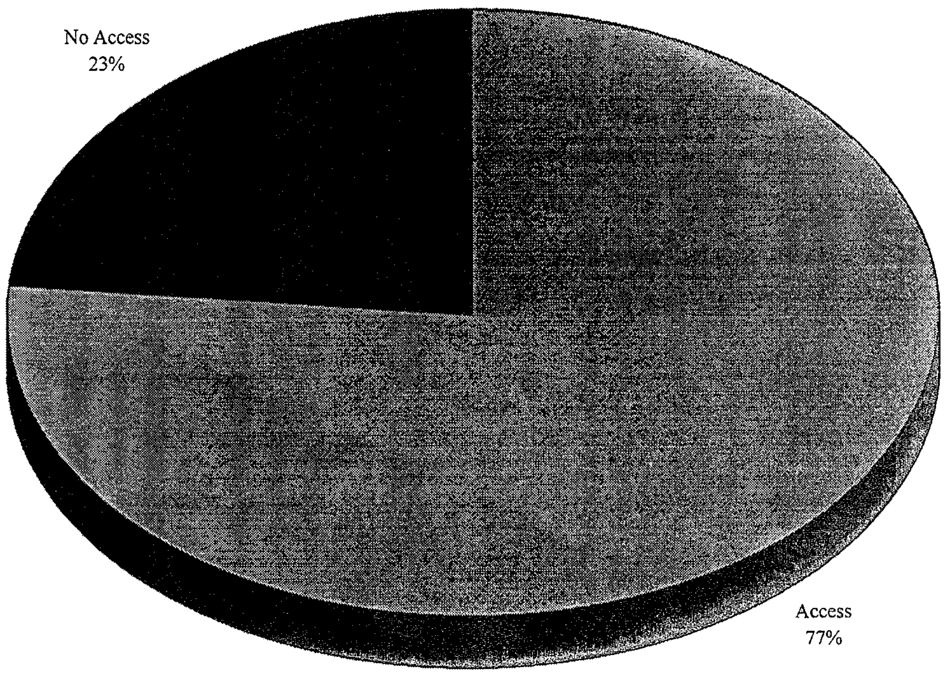

Figure 26. Question 2, Access to a Computer.

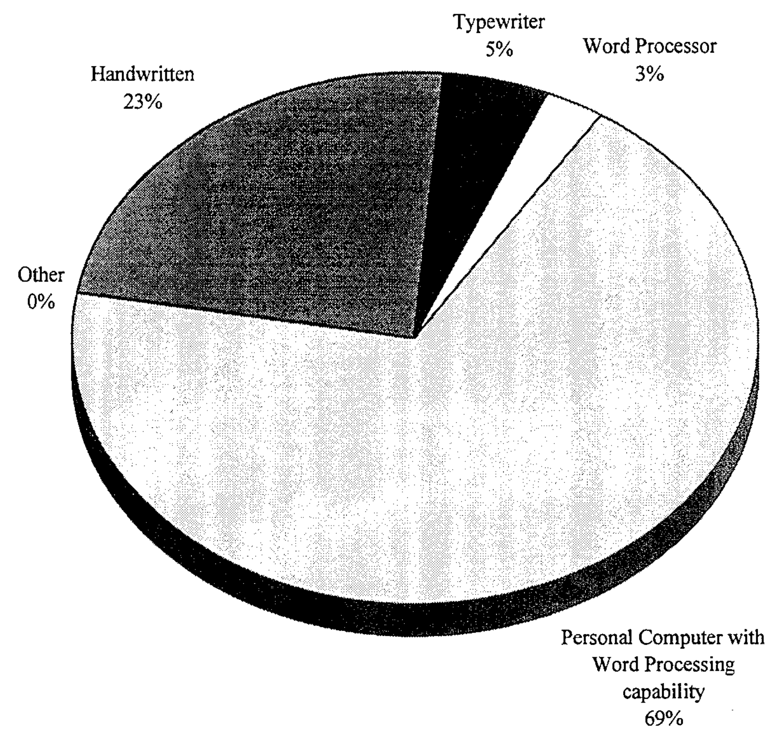

Figure 27. Question 3, How Written Documents are Composed.

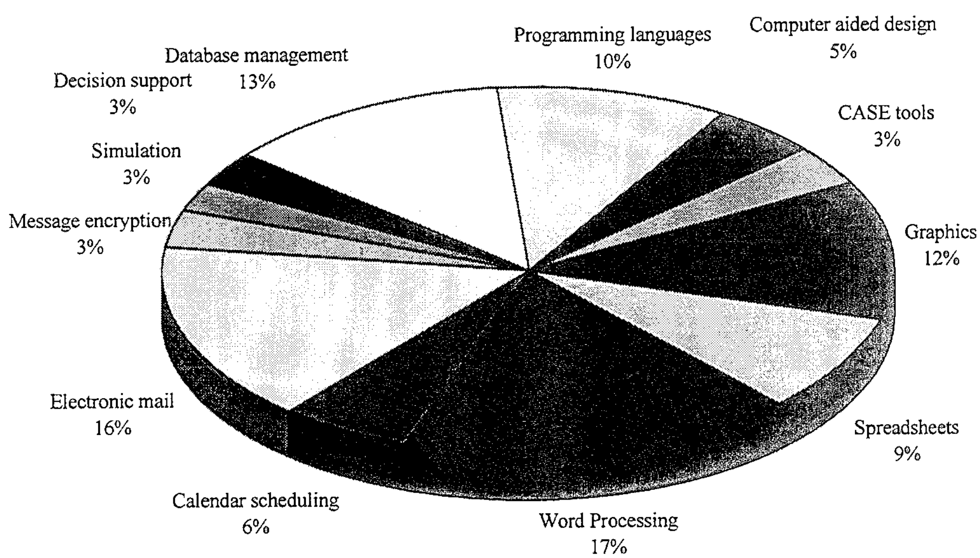

Figure 28. Question 4, Kinds of Software to Support Courses.

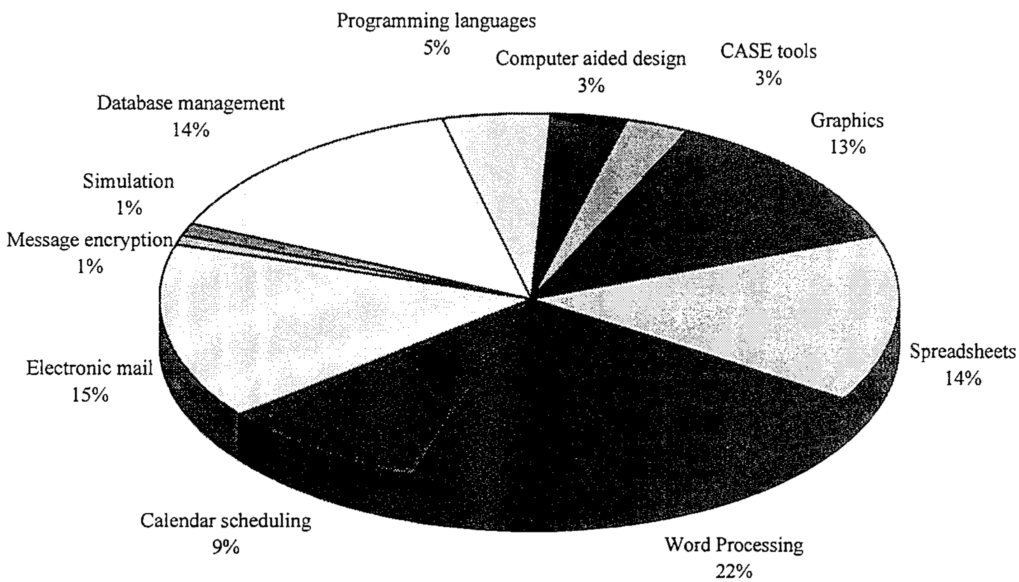

Figure 29. Question 5, Software for Personal Applications.

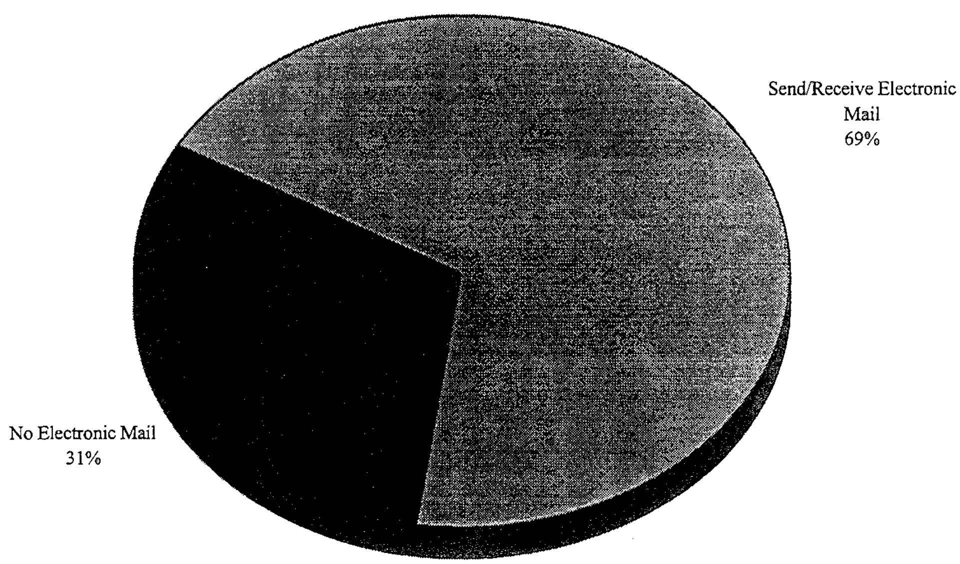

Figure 30. Question 6, Need to Send/Received Electronic Mail.

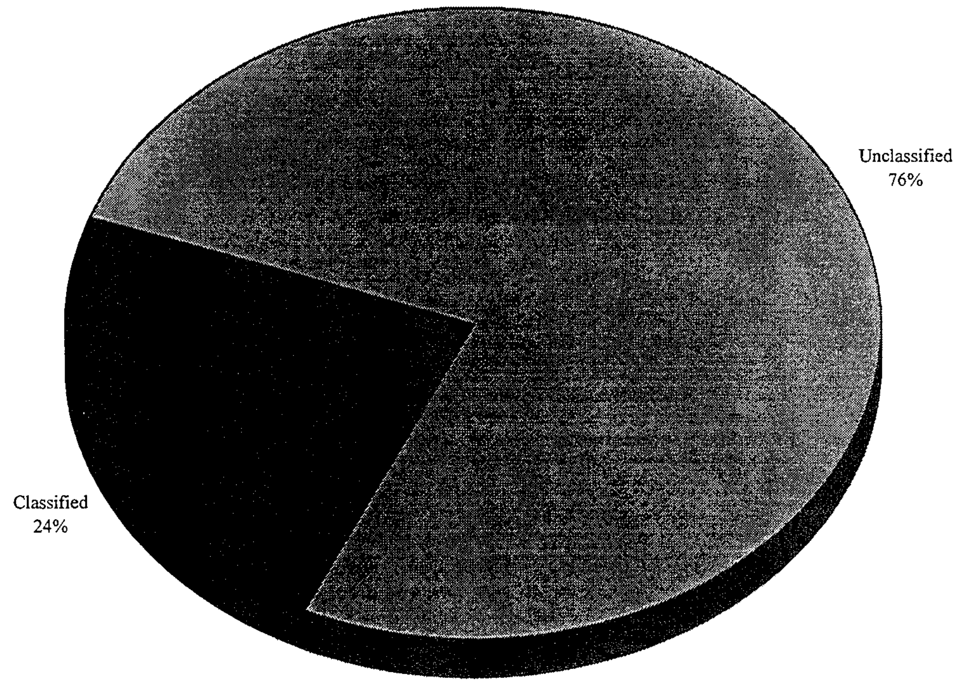

Figure 31. Question 7, Classified Communications.

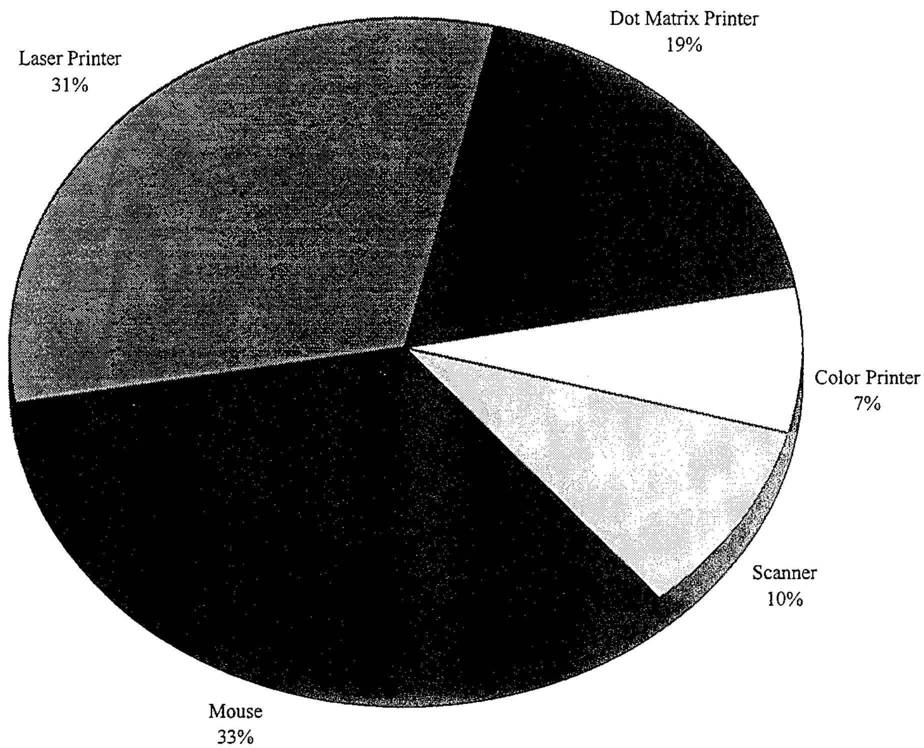

Figure 32. Question 8, Equipment Required.

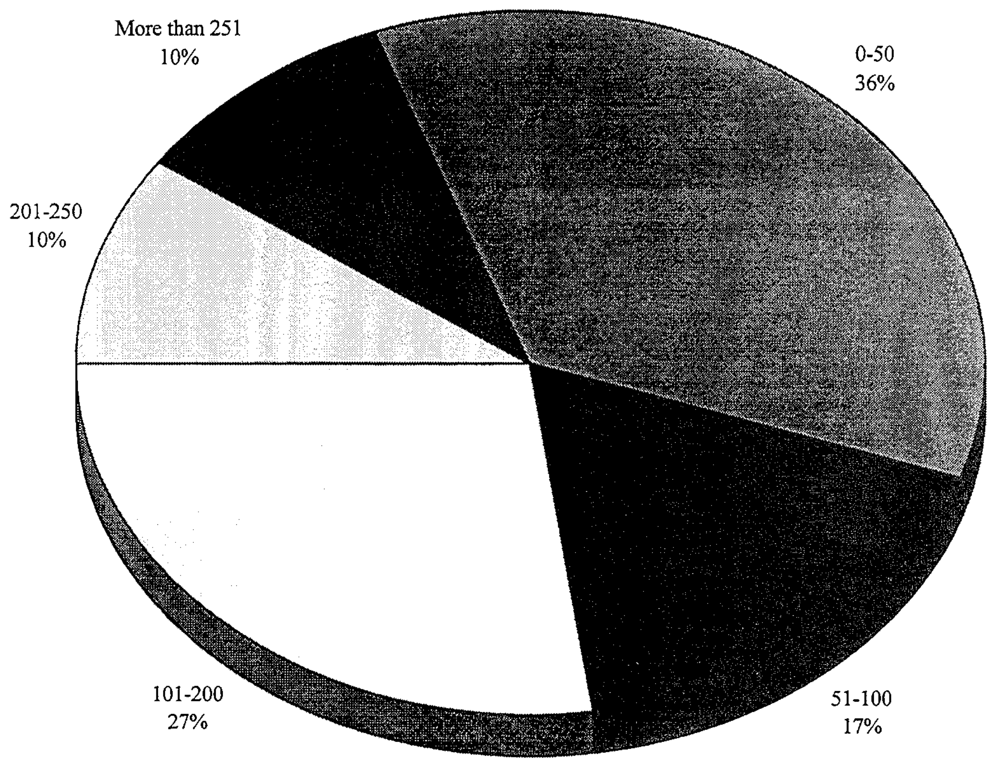

Figure 33. Question 9, Approximate Pages Printed / Week.

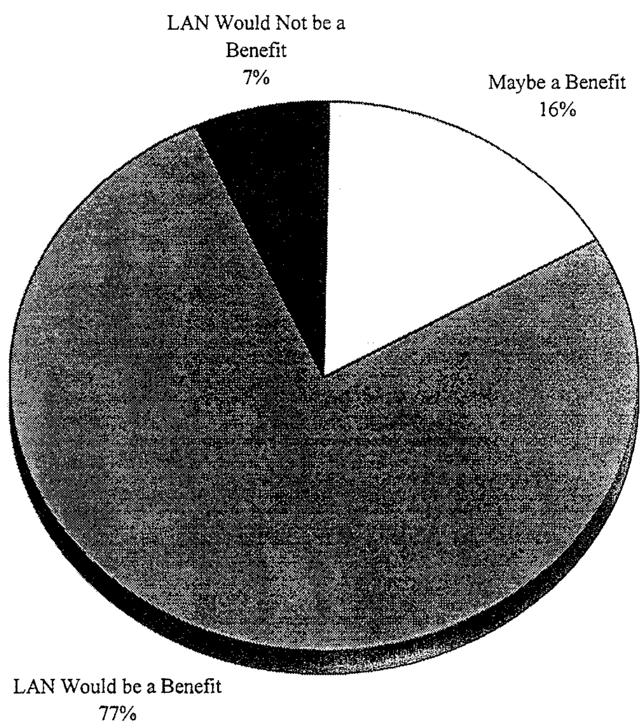

Figure 34. Question 10, Would a LAN be Beneficial.

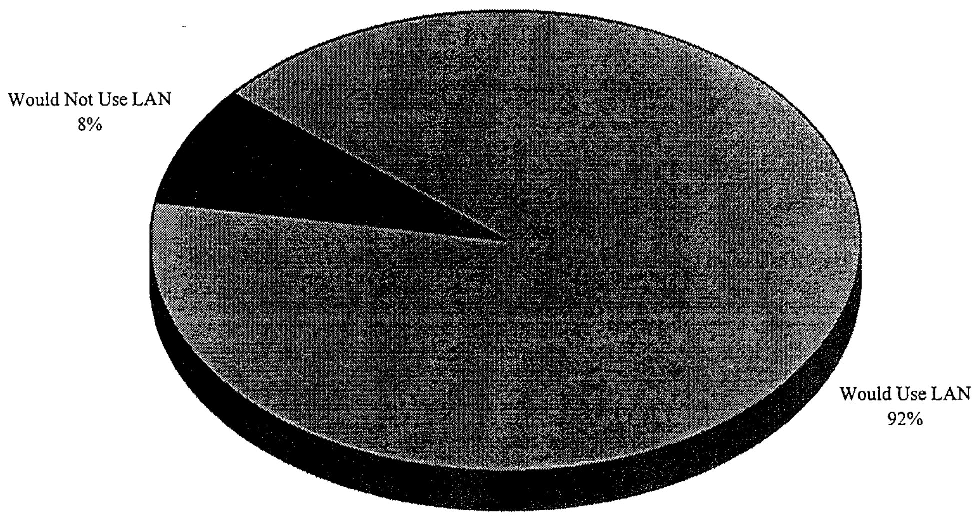

Figure 35. Question 11, Would Use the LAN System.

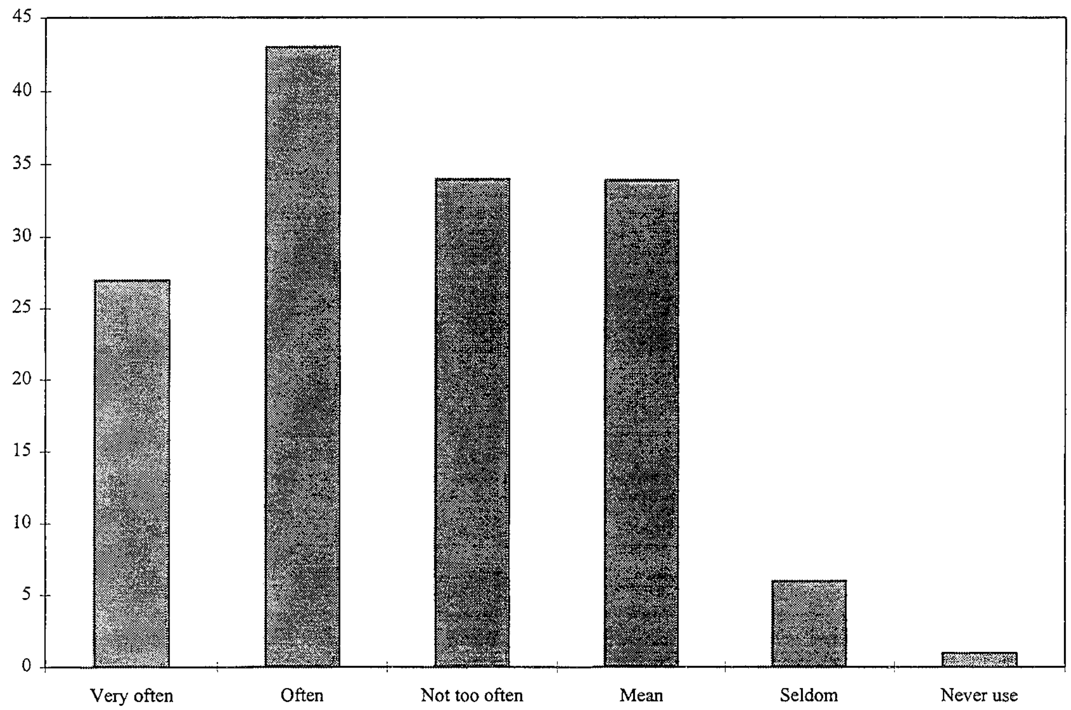

Figure 36. Question 12, How Often Certain Activities Will Be Performed.

APPENDIX C. ABBREVIATIONS AND ACRONYMS

ARP	Address Resolution Protocol
BBS	Bulletin Board System
C^4I	Command, Control, Communication, Computer and Intelligence
CSMA/CD	Carrier Sense Multiple Access/Collision Detection
DAC	Dual Attachment Concentrator
DARPA	Department of Defense Advanced Research Projects Agency
DOD	Department of Defense
DOS	Disk Operating Systems
FDDI	Fiber Distributed Data Interface
FTP	File Transfer Protocol
HDLC	High-level Data Link Control
IP	Information Technology
IPX/SPX	Internetwork Packet Exchange/Sequenced Packet Exchange
ITRC	Industry and Technician Research Center
LANs	Local Area Networks
MAUs	Multistation Access Units
MIC	Medium Interface Connector
MTBF	Mean Time Between Failures
NIC	Network Interface Card
NII	National Informaiton Infrastructure
NOS	Network Operation System
OSI	Open Systems Interconnection
RARP	Reverse Address Resolution Protocol
ROC	Republic of China
ROCNA	Republic of China Naval Academy

SAC	Single Attachment Concentrator
SDLC	System Development Life Cycle
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SOP	Standard Operation Procedure
STP	Shielded Twisted Pair
TANet	Taiwan Academy Network
TCP/IP	Transmission Control Protocol/Internet Protocol
UDP	User Datagram Protocol
UTP	Unshielded Twisted Pair
WFW	Windows for Workgroups
WWW	World Wide Web
XNS	Xerox Networking System

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